Aerial Panorame of Consolidated, San Diego Division, Plants I and II, showing North Island, Point Loma, and Coranado Island. 16 Feburary, 1942

Consolidated Vultee Aircraft Corporation

San Diego, California

B-24

PRODUCTION AND CONSTRUCTION ANALYSIS

Prepared by:

Air Technical Service Command
Western District Headquarters
T-5 Research Office

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People Contacted
In Connection With
Consolidated, San Diego, Study

Acknowledgement and appreciation is made to the spirit of cooperation existing within the Contractor's organization during the period required for the study covered by this report. Outstanding assistance and aid were offered by the following individuals:

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Mr. R. M. Andrews	Wage & Salary General Supervisor
Mr. L. C. Tompkins	Education General Supervisor
Mr. J. M. Kite	Plant Engineering General Supervisor
Mr. W. P. Taber	Industrial Engineering
Major L. C. Hall	Ass't AAF Plant Representative
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INTRODUCTION

This study of the construction and production program of the company designed B-24 airplane covers that part of the total program carried out by Consolidated Aircraft Company, San Diego, California, in facilities primarily owned by the company with a substantial addition built for and leased from Defense Plant Corporation. Consolidated and Vultee were combined in 1943 more than a year before peak production was reached.

This is one of a series of analysis made by the Air Technical Service Command of the industrial mobilization experience of World War II. It is the purpose of these analyses to review the problems encountered by representative industrial companies in the fulfillment of production contracts for airplanes and their equipment; and to provide the basic data for the development of industrial mobilization plans and policies for future emergencies.

The data prescribed in this study were compiled from official records and files of Headquarters, Army Air Forces, Headquarters Air Technical Service Command, Western District Headquarters, and Consolidated-Vultee Aircraft Corporation, San Diego, California. These sources were supplemented by personal conferences and interviews with both AAF and company representatives principally involved in the project. Briefs from the original documents and interviews used in the preparation of this study are filed at Headquarters, Western District, ATSC, Los Angeles, California, and are available for further study or reference by authorized persons.

PREFACE

The production of B-24 bombers at San Diego dates from the latter part of 1938, long before war thoughts entered the American public consciousness, when the Army asked Consolidated to inspect the Boeing B-17 at Seattle with the idea of becoming a secondary but large supplier. In reporting the company recommended that a new and better airplane, both tactically and production-wise, be produced. This was started in January 1939, flown in December 1939 and the first real production contract (with the French) was received in June 1940.

This dates the plane as pre-war in terms of lack of volume requirements, lack of combat thinking and the like, thereby laying the foundations for continuing and time-costly problems which delayed all producers throughout the program. Although rated better than the B-17 as delivered by the company's original promise, it was still in a general way a sister ship as the date of its birth was back in the peacetime period.

Like the design, the plants were pre-war in thinking and in actual construction, being largely completed and equipped by December 1941. In the size of the plants, though not in layout or equipment, one finds the first sign of the developing war program. Even the general planning was strictly pre-war, for it called for the solution of the complete production problem within the walls of the company's own (and DPC leased) plants, without subcontracting.

It is indeed a tremendous achievement to attain a peak production of 270 B-24 airplanes per month by the summer of 1944, particularly since this was accomplished while assisting four other plants to get into production on the same airplane and while this plant was producing other models for the Navy. It would be a tremendous achievement for any company under any conditions to explode in this way and to this extent, but it is particularly noteworthy when considering the pre-war character of everything and everyone connected with the undertaking throughout its early production planning and acceleration period. Too much consideration cannot be given to this pre-war dating and all that it means, in weighing the results of this program, or planning others for the future, nor will it ever be possible to over-evaluate the importance of maintaining the post-war know-how so sadly lacking in those pre-war days and acquired at such terrific cost of time and money. This "know-how" has been largely dissipated already, but action is most urgently recommended now to prevent further loss of this most important asset in the National Security Program.


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Earliest Aerial View of Plant 1 after completion of Bldgs. 2 and 3, before paving [illegible]

Photo taken 29 January, 1941

SUMMARY AND CONCLUSIONS

Additions to Plant #1 and the construction of Plant #2 were designed and constructed under peacetime conditions, being virtually completed on the first day of war, and in normal time with only normal peacetime delays. Production acceleration also proceeded by these same peacetime requirements. The year 1940 can be dropped from the record while considering time against American contracts, yet the French contract did render a most important service in causing the organization to raise its sights and begin to prepare for war. Once production really started in the summer of 1941, the curve was remarkably smooth and the rate steady to the peak in the summer of 1944. In retrospect it is apparent that the company was always ahead of the Army in its planning, as a few airplanes were always in reserve to absorb the shocks of the constant stream of difficulties. The schedule curve was too steep in the early stages as was the case in other plants where it was found impossible to predetermine the position on the learner's curve (then unknown) and its effect on deliveries. The other major dip in 1943 resulted from inability to accurately predetermine the number and time-cost of the engineering changes required by the Army.

Basic Production Plan:

The original plan was to produce the airplane on site by timeworn methods through the additional facilities at Plants #1 and #2 and without subcontracting or the use of new techniques. The original volume and the early increase in volume never required anything more elaborate and the planning therefore was sound though actually nonexistent. However, the first of April 1941 the lack of detailed planning became evident and the Production Planning Section was established.

From this point, with volume increases being asked more frequently by Army the final complicated production program developed smoothly and with no radical changes of pace or course. Subcontracting came into the picture one item at a time. Feeder plants were also added one at a time and without policy change to meet the growing need to take more work to the worker. The airplane itself was progressively broken down into smaller and smaller unit assemblies, the tooling program became resultingly more complicated, and ever more manhours per hour were applied to the schedule to meet its deliveries.

Construction Period:

When this going company accepted increasing production responsibilities, the first two steps were to increase the capacity of its existing plant. The first step beginning in December 1939 provided additions costing five million dollars and added one million square feet by February of 1941. The next step, started in April of 1940

and completed for use in February 1942, was the twenty-three million dollar project from which came Plant #2 with one million eight hundred seventy-six thousand square feet.

The speed records were better than many later construction programs because this was definitely peacetime procuring and building. The records were excellent in their own right due to the early establishment within the company of a complete and sound plant Engineering Department which turned its layouts over to the best of industrial architects and builders.

Pre-Production Period:

Had the company faced the problem in the winter of 1938-39 of preparing to produce 270 B-24's in any near future month and setting up an organization to maintain such a schedule, it no doubt would have been completely overwhelmed by the magnitude of such a project. Coming as the volume did in relatively small increments, it was possible and it now appears to have been necessary to continue with existing methods of building planes and then changing slowly as it became obviously impossible to meet requirements at various points on the acceleration curve with the old methods then in use.

In general summary the following factors served to prevent any more rapid acceleration had such been required:

1. The Contractor had no experience in volume production. It had good engineers and good mechanics who knew how to build good airplanes.

2. The pre-war design was not satisfactory during the early years either to the Army or to the company production men. It is now said truly enough that engineering never did catch up. Day by day it permitted other departments to move, but no long range detailed planning could be done.

3. In the absence of an "engineering package" and a definite Army expression of ultimate requirements, a situation was created which would have caused serious losses of production and schedule interruption, but for the company policy of playing safe. This resulted in the constant availability of just a little extra all along the line which many times later permitted meeting production schedules which otherwise would have been impossible.

4. The lack of forward planning on the project, which proved to be impossible due to the continuous lack of information, caused a manpower situation which constantly jeopardized the entire program. The rapid influx of this unexpected increase in population, in addition to that required for steadily increasing Navy programs, increased

the size of the community about 50%. Lack of manpower made it essential to gradually subcontract 50% of the B-24 manhours in order to maintain schedules. At no time was there any sign of competent authoritative manpower budgeting. People were hired as rapidly as possible which meant in the early stages of plant growth that too many people per day were sent to the production line.

The possibility of partial failure as it appeared almost daily was averted by one or more of the following favorable factors:

1. The original organization knew how to build airplanes.

2. The initial expansion of facilities, equipment, manpower, etc., took place prior to the accelerated growth of the nation's war plants.

3. All out effort was applied to the project by management, supervision and shop personnel with complete disregard for human physical limitations.

Production Period:

Reviewing the whole situation, it is considered that the Contractor did an outstanding job, that their acceleration curve was daily better than they themselves believed possible. The first two years contributed the basic airplane, and a lot of indirectly valuable know-how, though nothing in the way of American type volume production. Had the peak load been thrown on the company at a later stage in its growth, much more rapid acceleration would have been achieved. It is felt that the present estimate of twelve to eighteen months for the same job under the following ideal conditions is entirely reasonable:

1. The present state of completion of the B-24 designs for tools and airplane.

2. Freezing the present designs for the acceleration period.

3. The present degree of know-how within company ranks.

4. A single Government control of all factors within and without the company affecting the procurement of its requirements of materials and manpower.

5. The existence of plant space and equipment, including one set of complete tooling.

Finally, it must be observed that production of 270 B-24's per month does not represent mass production in any sense of the word. It is merely large volume manufacture of an article designed by men

without production experience, men who do not know how, in the industrial sense of the word, to make the parts and assemblies they design. True mass production of this type of airplane could only be had with a new plane to be designed in a company matured by years of volume production and by engineers personally experienced in fabricating and assembling airplanes.


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Final Assembly Line, Bldg. 4, Plant 1. 21 February 1944

RECOMMENDATIONS

As a result of their years of experience and recent weeks of study by individual executives of the corporation and the San Diego Division, come the following recommendations during two weeks of intensive discussion with the Army team. These are believed necessary to the accomplishment of the objectives in the next emergency; first, to accelerate in the shortest possible time to a sustained production of 270 airplanes (B-24 type) per month, and second, to help establish an industrial organization with which the next war can be won. The B-24 airplane is used as a subject of the discussion only because its problems are known, and not with any idea that it will actually go into production again.

The B-24 production acceleration problem has been studied in great detail with especial attention given to all factors which might change during peace years to shorten the period for the next war. The study suggests a conclusion believed to be sound that a period of not more than eighteen or less than twelve months will be required to reach a peak of 270 airplanes of B-24 type, and that during this period an organization may be built to sustain such production level, provided the following recommendations are effective in practicable form on D-Day.

While these recommendations are not necessarily expressions of Division or Corporation policy, nor statements of official opinion of the Research Office, Headquarters, WDAFSC, the required improvements are:

1. Complete and continuous pre-planning in which they desire to participate.

2. A national service act is required to provide for complete control of all manpower. This should insure that existing organizations of key companies such as this one from which tremendous expansions are to be required, are absolutely protected from depletion by the draft. In the face of an all-out industrial war, transfers from industrial to military service should not be permitted or made. If such transfers are required by sheer necessity, they should be preplanned in detail, and the company should set up an orderly withdrawal schedule.

3. The establishment of a local representative of Government having final and complete authority and responsibility to make and administer the contracts in all respects. This office to be staffed with a handful of highly trained and highly competent men (peacetime reserve).

4. The pre-preparation and constant maintenance of an engineering and production package by models to include:

a. Complete engineering information - detailed drawings, standard reproducible lofts, specifications for materials, equipment and inspection.

b. Complete production information - detailed production planning paper covering everything necessary to procure, store and move the materials and components, to fabricate parts, and to make all sub and final assemblies.

c. Complete tooling designs, and one set of production-proven high-production tools ($5,000,000 cost on a B-24 type airplane) with two complete sets of control master gauges to locate all mating holes and contours.

d. Complete parts lists and bills of material.

5. A complete freeze of design for the production acceleration period.

6. A new AAF Engineering Change procedure which will insure that no change will be ordered into manufacture unless the tactical advantage is worth more than the industrial cost.

7. The continued use of the modification system under company control to free production lines of minor and super-urgent change requirements.

8. Only one model to be placed in production for one service in one plant at one time. This does not eliminate the possibility of replacing an old with a newer model after peak production is reached, nor one service procuring airplanes for another.

9. The Army to establish a standard drawing room practice so that all drawings, prints and specifications for military airplanes shall be alike.

10. The Army to stockpile 150 plane sets per model of materials and components of a critical nature, constantly reducing and rebuilding stockpiles as peacetime development and production operations progress.

11. The Army to work out with industry a target price contract to replace CPFF for peacetime procurement of (1) product development, (2) small volume production of accepted models, and (3) building and proving of production tools and all planning paper. This contract is to be drawn to eliminate the general accounting office except in case of fraud.

12. The company to be given final control of all housing available for occupancy by its employees.

13. The Army to give and the company to take complete responsibility for the operation of the plant and details of the product. General specifications to be given by Army and planes to be delivered on flight line for acceptance in general, not in detail. Army inspection to be limited to one man checking the company inspection operation and technical processes used in manufacture.

14. More complete standardization and a single set of industry standards to eliminate company, Army, Navy, AN, CAA and Federal standards.

15. A positive standardization by industry and Army of all such items as might be used on more than one plane model. Examples - electric motors, valves, extrusions.

16. No more GFE or the elimination of "accountability" by permitting company to purchase and handle in plant by standard practices.

17. On multiplant production programs on a single model, the coordination committee should be established and the associate plants designated at the time of Army acceptance of new models.

18. On multiplant production programs on a single model, and after designation, associate primes should be given small contracts to cover work of developing and coordinating production planning and master tooling.

19. Government representative at design prime plants should control Government representatives at associate prime plants.

20. Government representative at design prime plant should coordinate early production in associate plants to distribute fabricated parts and sub-assemblies to secure earliest maximum complete airplane deliveries from the program as a whole.

21. On all new models Government should specify peak production requirements with military requirements in the first request for design proposal.

22. On all new models the company should include production planning and methods with engineering in the planning of basic designs and the development of detail drawings.

23. Spare parts program to be completely preplanned by items and requirements, and complete lists of requirements to be constantly maintained with design prime contractor as a supplement to his production contract.

24. On multiplant production programs on a single model, all spare parts requirements to be filled by a single plant for the total schedule. This plant preferably not to be engaged in production of complete airplanes.

25. The specialized depot (spare parts) should be operated by the company and adjacent to its plant.

26. Spare parts should be delivered by air direct from this one depot to combat groups in operating theatres without intermediate stock piles or pipe line.

27. Contractor should be permitted to fly to destruction if necessary, the prototype airplanes to determine characteristics before either company or Army give much attention to the details of equipment to be installed in production.

28. Final authority for design changes should be vested in the Government representative on site.

29. The machine tools needed for required expansion should be issued by Government, rather than issuing paper priorities.

30. A program must be developed at once by industry and Army to safeguard and expand the present stockpile of management and supervisory "know-how", which is already being depleted at an accelerating rate.

THE PRODUCT

In the fall of 1938 Consolidated Aircraft Corporation was invited to submit a proposal for building Boeing's B-17 type airplane for the Army. Consolidated felt that the B-17 design was incomplete and that the method of construction would be difficult to use in their shop. Using experience gained in building flying boats for the Navy, the Contractor, early in 1939, designed and submitted a proposal to build the XB-24. In March 1939 a contract was received to construct the XB-24, followed in April by an order for 7 B-24's and in September by an additional order bor 38 more. During the early stages of production the French Government negotiated for the procurement of 139 B-24 type airplanes. After French capitulation, the British took over the French contract and the airplane was known as LB-30. As an aid to the sorely pressed British, the initial output of the plant was diverted to them by the Army. Tactical experience gained by the British caused the Army to require the addition of turbo-superchargers, power turret and other tactical changes which made up the B-24D. Delivery to the Army did not start until September 1941.

Design & Development:

The Contractor designed the XB-24 in answer to the Army request for a heavy long range bomber similar to Boeing's B-17 Flying Fortress. There was no predecessor model to the B-24 bomber. However, during negotiations for the original XB-24 airplane contract, the company was testing an experimental flying boat known as Consolidated Model 31, which embodied the Davis wing and a twin tail similar to that proposed for the prototype B-24.

The original B-24 was an all metal high wing monoplane with four Pratt & Whitney R-1830 engines, twin tail surfaces, retractable tricycle landing gear and hand held 30 cal. machine guns. The gross weight was about 41000 pounds. After combat experience was gained by the British with the LB-30 turbo-superchargers, selfsealing fuel cells, 50 cal. machine guns, power turrets, hydromatic, constant-speed, full-feathering propellers and camouflage finish were engineered and added.

Engineering improvements were constantly and rapidly made. The first model to be put into large scale production was the B-24D. The B-24D had a wing span of 110', a length of 66'4", a height of 17'11" and an approximate weight of 60,000 pounds. The four power plants were Pratt & Whitney R-1830 14 cylinder, rated at 1200 horsepower and suspended from the center wing section. Considerable

FIGURE RIGHT SIDE VIEW OF COMPLETE AIRPLANE

C32-1407-A

B-24J Model. C.V.A.C. Ship number 4317. Photo taken 14 April, 194

armor was added for crew protection. Armament consisted of ten or more 50 cal. guns, including two waist guns and a nose, top, ball and tail turrets. The B-24 carried a bomb load of eight 1600 lbs. bombs.

Production Experience and Complexity:

The Contractor had considerable aircraft experience in building heavy flying boats for the Navy. This experience contributed directly to the design know-how of the B-24 type airplane. The manufacture of flying boats for the Navy enabled the Contractor to build the organization which later expanded for the war production.

Changing war requirements necessitated the large volume of engineering changes and the engineering department never quite caught up. The B-24 type airplane was built at Ford Willow Run; North American, Dallas; Douglas, Tulsa; Consolidated-Vultee, Fort Worth; in addition to Consolidated-Vultee, San Diego. The B-24 was considered an easy airplane to build among the heavy bomber class.

THE CONTRACT

During the latter part of 1938, the Army Air Forces asked Consolidated to consider the building of Boeing's B-17 airplane to provide two sources for this four engine bomber. Therefore, San Diego personnel visited Boeing's plant in Seattle to study this pro-.ram, and as a result of this study decided with Consolidated management that a new bomber could be designed and produced much easier and faster.

Based on the above decision, the Army asked for preliminary design and quotations for such a new bomber. Work was started immediately and when completed in January 1939, the proposal was taken to Wright Field. Negotiated contract (W 535 ac 12436) was agreed upon in February 1939 and signed 21 March 1939 for one prototype airplane, one wind tunnel model and one mockup at a total cost of 320,000 dollars. The prototype airplane was to be delivered in December 1939. This contract was immediately followed on 26 April 1939 by contract No. W 535 ac 12464, calling for seven additional B-24's at a total cost of $2,880,000 including approximately 13% spares. Delivery was to begin with one airplane in May 1940 and three per month thereafter until completion.

During the early stages of production on the above contracts, the French Government negotiated with Consolidated for the procurement of 139 B-24 type airplanes and signed a contract for this amount on 4 June 1940. This is considered the first real production contract as all preceeding contracts were too small in quantity to enable the contractor to use production breakdowns to any extent. Contingent on satisfactory performance of the aforementioned contracts, and as additional appropriations became available to the Air Forces, a large scale production program for B-24 type airplanes was planned as evidenced by additional Fixed Price orders as outlined below:

Contract W 535 ac 13281 entered into on 12 September 1939 called for the delivery of 38 B-24 type airplanes at a total cost of $8,613,674, including approximately 7% spares at a unit cost of $223,300, with the following delivery schedule: 1 - October 1940, 1 - November 1940, 2 - December 1940, 2 - January 1941, 3 - February 1941, 4 - March 1941, 4 - April 1941, 5 - May 1941, 5 - June 1941, 5 - July 1941, and balance of 6 in August 1941.

In view of the combat experience gained by the British on the LB-30, certain improvements such as leakproof tanks, turbo-superchargers, and power turrets were required by the Army, and therefore Change Order No. 5 to this contract, dated 24 June 1940, was issued to incorporate the above and redesignate the airplane "B-24D", which subsequently became the first production article for combat use after U.S. entry into the war. This change order increased the number of airplanes by 58 for a total of 96, with an increase in total cost, including spares, of $10,577,245.40, or a unit cost of $177,954.09. This change order further revised the entire delivery schedule to be as follows: 4 - November 1940, 5 - December 1940, 7 - January 1941, 8 - February 1941, 8 - March 1941, 8 - April 1941, 4 - May 1941, 7 - June 1941, 10 - July 1941, 13 - August 1941, 16 - September 1941, and balance of 4 in October 1941.

Contract W 535 ac 16005 entered into on 18 September 1940 called for the delivery of 352 B-24D airplanes at a total cost of $85,008,000, including approximately 5% spares, at a unit cost of $230,000, with a delivery schedule as follows: 14 - August 1941, 29 - September 1941, 32 - October 1941, 27 - November 1941, 30 - December 1941, 26 - January 1942, 33 - February 1942, 33 - March 1942, 32 - April 1942, 32 - June 1942, and balance of 32 in July 1942.

Contract DA W 535 ac 4 entered into on 21 May 1941 called for the delivery of 730 B-24D type airplanes at a total cost of $226,636,200, including approximately 17% spares at a unit

cost of $269,805, with a delivery schedule as follows: 15 - December 1942, 35 - January 1943, and 35 per month thereafter until completion of the contract.

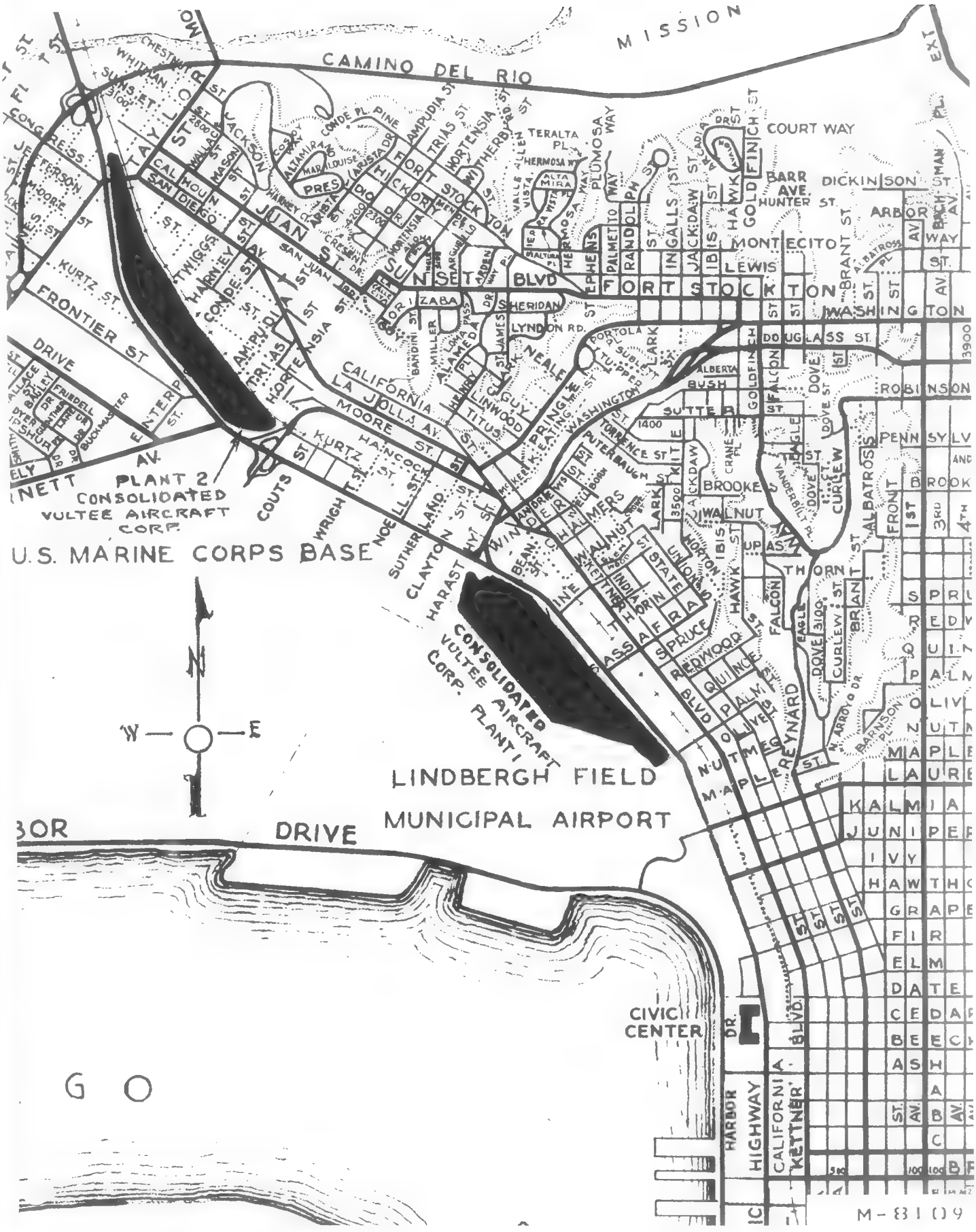
Contract W 535 ac 24620 entered into on 19 February 1942 called for the delivery of 1200 B-24D airplanes at a total cost of $329,444,515.80, including approximately 13% spares at a unit cost of $238,727.91, with a delivery schedule as follows: 45 - March 1943, 100 - April 1943, and 100 per month thereafter until completion of the contract.

Contract W 535 ac 30461 entered into on 29 June 1942 called for the delivery of 750 B-24D airplanes at a total cost of $150,937,500, including approximately 13% spares at a unit cost of $175,000, with a delivery schedule as follows: 80 - September 1943, 136 - October 1943, and 136 per month thereafter until completion.

Contract W 535 ac 35312 entered into on 21 November 1942 called for the delivery of 900 B-24J airplanes at a total cost of $181,125,000, including approximately 13% spares, at a unit cost of $175,000, with a delivery schedule as follows: 61 - November 1943, 200 - December 1943, 210 - January 1944, 220 - February 1944, 209 - March 1944. Later, Contractor voluntarily reduced the unit cost per plane to $137,000.

Contract W 535 ac 40033 entered into on 4 February 1944 superseded letter contract dated 14 April 1943 and supplement dated 21 May 1943 and called for the delivery of 4500 B-24J airplanes (to be produced jointly by the San Diego and Ft. Worth Divisions of Consolidated) at a total cost of $712,468,500, including approximately 13% spares, and also including the provision that Contractor was to furnish all special tools and ground handling equipment necessary to properly service B-24 type airplanes currently being produced by Douglas, Tulsa; North American, Dallas; and Ford Motors at Willow Run which amounted to $3,493,500 of the above stated amount. The unit cost of these airplanes was $137,000 with a delivery schedule as follows: 111 - February 1944, 275 - March 1944, 255 - April 1944, 266 - May 1944, 257 - June 1944, 251 - July 1944, 256 - August 1944, and 240 per month thereafter until completion of the contract.

It is to be noted that although the above contracts were awarded in sufficient numbers (except in the very beginning) to preclude gaps in the slowly growing production line, company policy dictated that the planning must always be ahead of contract issuance in order to meet anticipated schedules subsequently imposed upon production lines as the war progressed.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CALIFORNIA
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M-8109

monorail type cranes cover the entire assembly area.

In Plant #1 are two main manufacturing buildings having dimensions 200' x 1500' and 360' x 720', Clear space under cranes is 26'. Columns are spaced on 25' centers. In the long "final assembly" building there are two doors at each end 99' x 30' (door clearance), and one door in the east elevation 48'10" x 30'. All large doors throughout the plant are horizontally sliding doors hanging on overhead rails. In the other main manufacturing building are the following doors: In the north elevation one door 86' x 36'; in the west elevation two doors 83'10" x 36' and four doors 118' 10" x 36'; in the south elevation two doors 83'10" x 36'. These buildings are supplemented by office, engineering, experimental, storage, and miscellaneous buildings making a total area of 2,303,496 sq. ft. The experimental building has a door in the west elevation with a clearance of 149' x 40'.

In Plant #2 are three main manufacturing buildings each 400' x 750', divided into four bays 100' wide with steel columns spaced on 25' centers and 26' clearance under cranes. In each of these three buildings in both the north and south elevations are doors all 99' x 36', and in the east elevation are doors all 48' x 36'. In addition there is a paint shop 100' x 400', a three story drop hammer building 80' x 240', shipping building 100' x 400', two story office building 50' x 750', boiler and compressor house, and small miscellaneous buildings making a total of 1,876,215 sq. ft.

Total area of Plants #1 and #2, feeder plants and warehouses is 4,493,716 sq. ft.

There is adequate administrative and shop office space, cafeteria and dining room facilities, toilets and rest rooms, training area, special testing facilities, and automobile parking space.

The plant is situated on and uses the facilities of the municipally owned Lindbergh Field, the commercial airline port for San Diego. This field has two concrete landing strips of sufficient length and design strength to allow their use by modern very heavy bombers. In addition and adjacent to the field there is a large marine ramp for the launching of amphibious planes and flying boats.

This plant was originally designed and built for the production of large two and four engine naval aircraft. Therefore, the large open areas were readily adapted for production of the B-24 and could be utilized for all classes of heavy aircraft.

Utilities and Services:

The plant is adjacent to the Atchison, Topeka and Santa Fe main line and has spur tracks running into both Plants #1 and #2. Public utility companies furnish the gas and electricity, the latter being generated at Boulder Dam with local steam plant used as emergency and peak standby. Water and sewage services are furnished by the municipality. All service connections were single although backed up by standby capacity. The water supply proved just adequate during the emergency because of unusually heavy runoff. Additional sources, Boulder Dam for example, will be required to safeguard future peak operations.

The public highway running along between Plants #1 and #2 is a modern divided six-lane highway artery connecting San Diego and Los Angeles. Adequate bus service to and from the plant is available.

ANALYSIS OF CONSTRUCTION PROGRESS

Summary:

Beginning with a completely integrated but small aircraft plant in the fall of 1939, Consolidated grew to its present size in three major expansion programs and several minor ones. The first two major programs expanded the then existing facilities, now called Plant #1, and the third program resulted in the facilities now called Plant #2.

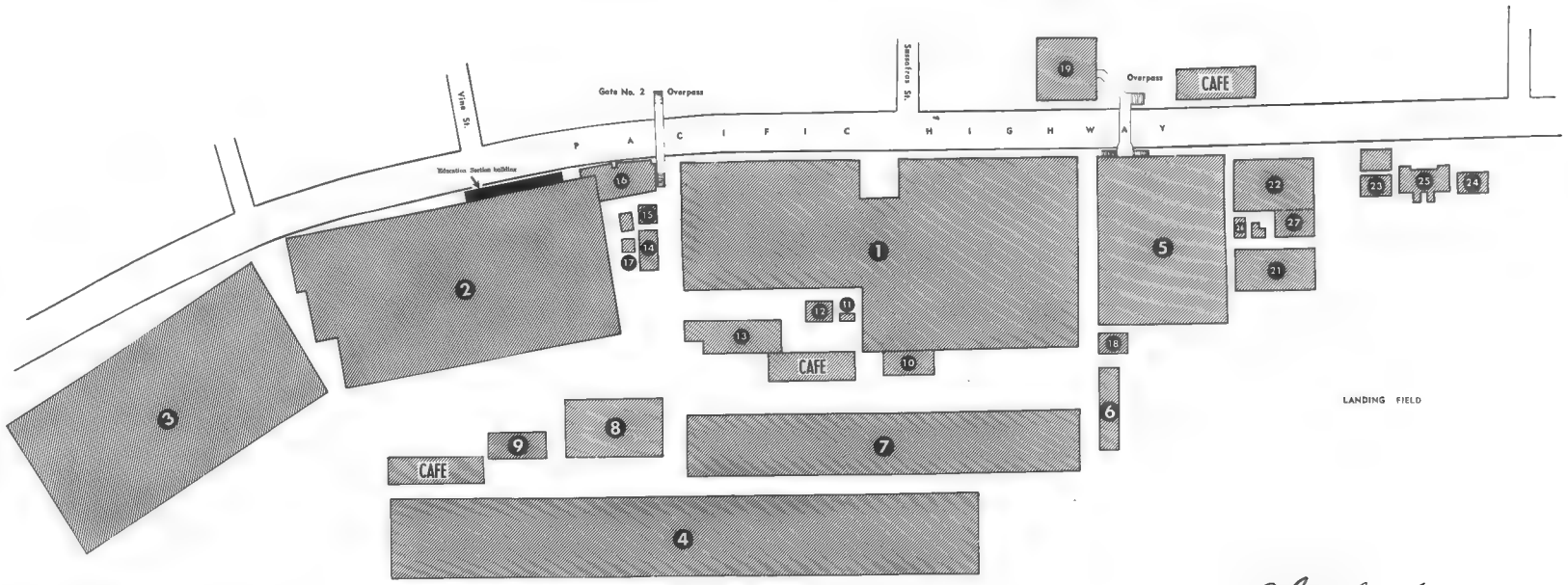
These programs are summarized in the following tabulation:

Program	Date	Area Added	Cumulative Area of Plant
1st Major Expansion	1939-40	410,000	1,000,000
2nd Major Expansion	1940-41	663,000	1,663,000
3rd Major Expansion	1941-42	1,700,000	3,363,000
Adm. Office Building	1942	157,000	3,520,000
Plant #1 Additions	1943	10,000	3,530,000
Plant #2 Additions	1944	176,000	3,706,000
Continuing Misc. Additions		473,000	4,179,000

Since the greater part of this expansion occurred before building materials became critical, construction in general progressed normally and no undue delays were experienced. Construction time was not a "bottleneck" and did not adversely affect production acceleration.

Early Planning:

It was evident by 1939 that the entire aircraft industry was due for a wartime expansion. European countries were contracting for planes in this country and our own military services, becoming



Produced by Visual Aids
Industrial Relations Department

Plant 1

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION

M-4505-A

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cognizant of the threat to our national security, were planning for expansion of tactical air units and negotiating for increased procurement of planes.

Consolidated was ideally located for the production of flying boats and had been so engaged up to this time. So when the Navy decided to procure additional flying boats in the fall of 1939, it was only logical that Consolidated should get a share of this business. Furthermore since the number of boats contracted for, 200 PBY's, was at that time considered quite a substantial order, it was evident that the existing plant would have to be expanded. Later expansions were planned and executed as the necessity arose.

First Expansion:

The following tabulation is a chronology of the first expansion:

Date	Event
1 Oct 1939	Architect selected
31 Oct	Bids obtained on structural steel plans
6 Dec	Foundation drawings released for bids
15 Jan 1940	Excavation for footing on first building began
31 Jan	All plans and specifications for general structures released for bids.
13 Feb	General structure bids received
15 Feb	Electrical plans and specifications released for bids
16 Feb	Steel sash proposal received.
29 Feb	Electrical bids received
6 Mar	Erection of steel in first building started
14 Mar	Heating & ventilating plans & specifications released for bids
20 Mar	Plumbing and heating bids received
8 Apr	Erection of steel in assembly building started
1 Aug	Approximately completion of construction
1 Aug	Approximate occupation of facilities and start of manufacturing operations

The architectural firm of Taylor and Taylor of Los Angeles was selected to draw up plans and specifications because Consolidated's previous experience with this firm had been very satisfactory. The architect was retained to prepare plans and specifications for the general structure only and to furnish architectural supervision of the construction.

Plans and specifications for the mechanical trades, electrical, plumbing, heating, monorail, etc., were prepared by members of Consolidated's Plant Engineering Department. Detailed inspection of the construction work was also handled by the Corporation's engineers and inspectors.

Competitive bids were taken on most of the work. The initial proposals covered the complete project. Individual fixed price contracts, however, were let for the various phases of the work and the Contractor acted as general contractor in letting these contracts and in supervising and coordinating the construction operations.

Negotiations in connection with the financing of this expansion extended over a long period of time. The program was started under a "Closing Agreement" which was approved in the fall of 1939, but after Consolidated had committed itself. This was subsequently changed to a Certificate of Necessity covering all work performed subsequent to 10 June 1940, and this was later modified by an additional Certificate of Necessity which covered all work performed after 1 January 1940, but previous to 10 June 1940. A final Certificate of Necessity was not issued until sometime subsequent to 1 January 1943.

This expansion consisted of a new assembly building, a new paint building for final finish of completely assembled airplanes, additions to existing buildings, the erection of mezzanines in existing buildings and miscellaneous smaller service buildings such as boiler house, storage sheds, etc.

At the time of the construction program there was no priority control, building materials were available, and the design was suitable for quick construction so that there were no delays other than those generally encountered in any program of this magnitude.

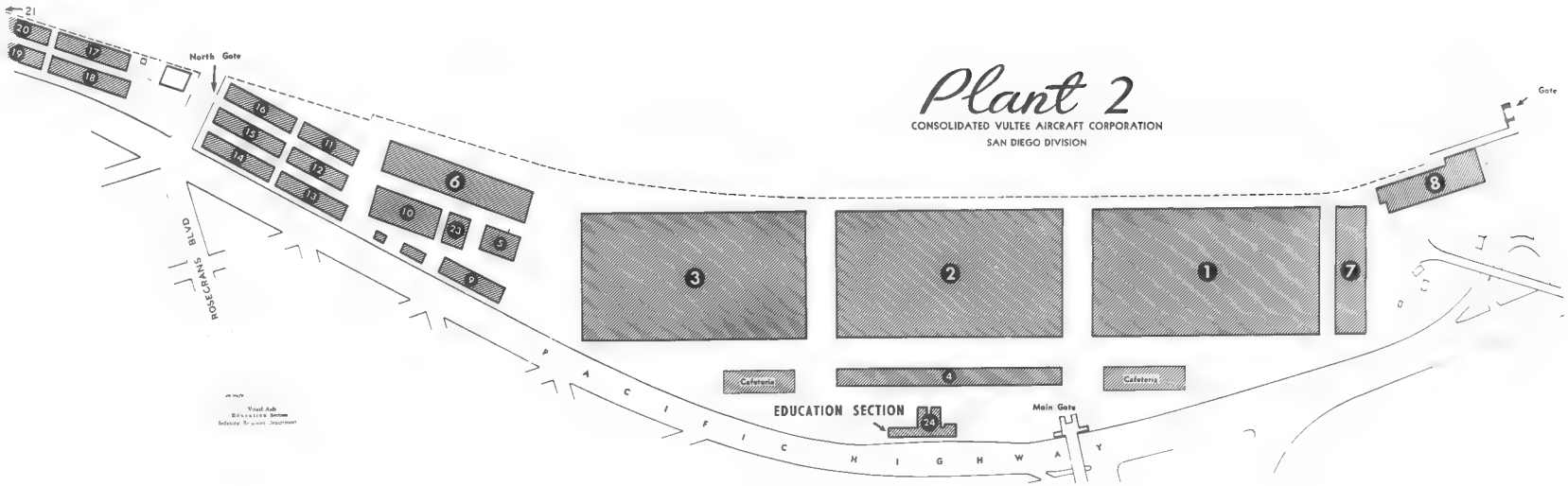
Because of the type and method of construction requiring the use of floor space exclusively for construction purposes, it was necessary to await virtual completion of the facilities before their occupancy. Canvas covered shelters, therefore, were used temporarily for manufacturing operations. It is desired to point out here that during almost the entire war period it was necessary to carry on some manufacturing operations in temporary structures and shelters.

The first major expansion amounted to an additional area of 410,000 sq. ft., which brought the total plant area to nearly a million square feet. The cost of the project was approximately $2,150,000.

Second Expansion:

The following tabulation is a chronology of the second expansion:

Date	Event
2 Apr 1940	Engineer contractor selected for Assembly Building #4.
2 May	Design drawings for Building #4 completed.


Plant 2
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION
North Gate
Gate
Main Gate
EDUCATION SECTION
Cafeteria
Cafeteria
ROSECRANS BLVD.
PACIFIC HIGHWAY
1
2
3
4
5
6
7
8
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11
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13
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19
20
21
24

M-4504-A

Date	Event
5 July	Decision made to increase ceiling height from 20' to 30'.
1 Aug	Architect selected for Assembly Building #3 and other small structures.
15 Aug	C.P.F.F. proposals on Buildings #3 and #4 received.
19 Aug	Construction drawings for Building #4 completed.
10 Sept	Pile driving began - Building #4.
20 Sept	Proposals on paint shop addition received.
23 Sept	Architects final construction drawings completed.
2 Oct	Pile driving began - Building #3.
5 Oct	Proposals on Plant Engineering Building received.
20 Oct	Proposals on Tool & Fixture Building received.
23 Oct	First structural steel erected - Building #4.
Oct	Final Government approval on entire project received.
3 Nov	First structural steel erected - Building #3.
12 Dec	Proposals on service tunnel received.
13 Dec	Proposals on boiler addition received.
1 Feb 1941	Approx. completion of construction.
1 Feb	Approx. occupation of facilities and start of manufacturing operations.

This expansion was divided into two parts, the first being a large assembly building 200' x 1500' (Bldg.#4) and the second being an assembly building 360' x 720' (Bldg.#3), an office building, addition to boiler house and paint shop and various other small structures.

Two firms, one for each part, were retained to design and supervise this expansion program. National Iron Works, San Diego, was selected to handle the first part and Taylor and Taylor, Los Angeles, was selected as the architects on the second. This was done for the purpose of comparing construction under an engineer contractor agreement with construction accomplished by sending out complete plans and specifications prepared by an architect and obtaining competitive bids from contractors.

The original plan was to utilize Building #4 for parts manufacture. After the preliminary design was completed, however, it was decided that the building would be used for assembly operations which necessitated an increase of ten feet in clear truss height. No other major design changes were made in this program.

The major portion of the work was performed under cost-plus-a-fixed-fee contracts.

The project was started under a Navy sponsored Emergency Plant Facilities Contract which was later changed to a Certificate of Necessity. It is interesting to note that this program was started

Aerial Photo of Plant 1, showing addition of Bldg. 5, completion of overpass. Photo taken 5 November 1941.

six months before final Government approval and at least three months before any financing agreement with the Government.

As in the first major expansion, there were no building material priorities or no delays in construction other than those normally encountered except for the fact that a shipload of structural steel was sunk near New Orleans and it was necessary to make some substitutions of steel section in order to prevent a delay in the fabrication of structural steel.

Because of the type and method of construction, occupancy of the buildings was not practical until they were virtually completed, necessitating the use of some temporary structures for manufacturing operations.

This expansion increased the area of the plant by 663,000 sq. ft. and the cost of the project was approximately $2,870,000.

Third Expansion:

The following tabulation is a chronology of the third expansion:

Date	Event
1 Aug 1940	Site selected.
10 Sept	Architect selected.
31 Oct	D.P.C. financial approval obtained.
5 Nov	Preliminary drawings completed.
16 Nov	D.P.C. Lease Agreement approved.
20 Nov	C.I.F.F. proposals on buildings received.
27 Nov	Contract for site fill and grading approved.
2 Dec	Filling of site began.
Feb 1941	Priorities on building materials first assigned.
11 Apr	First structural steel erected.
15 Oct	First building completed and occupied.
15 Jan 1942	Complete plant operation began.
June	Completion of entire project.

This project, Plant #2, was an entirely new facility and consisted of the following buildings: Three major manufacturing buildings 400' x 750', paint shop 100' x 400', boiler and compressor house 80' x 125', two story shipping building 100' x 400', two story office building 50' x 750', three story drop-hammer building 80' x 250'. These facilities were designed and used for the production of major assembly parts.

The firm of Taylor & Taylor, Los Angeles, was again selected as the architects for this program not only because they previously had been proven satisfactory but because they were thoroughly familiar with the Contractor's facility requirements.

15828 2-22-41
CONSOLIDATED AIRCRAFT CORP
VERTICAL OVER PARTS PLANT.

This photo and following five show construction progress made on Plant 2 (Parts Plant) between February and August 1941. This picture shows how construction work was halted due to site being covered with flood water. 22 February 1941.

15846 3-14-41
CONSOLIDATED AIRCRAFT CORP
DEFENSE PLANT CORP
PLAN COR-20, VERTICAL.

Plant II Construction Progress. Notice flood water still on portion of site. 14 March 1941.

15880 4-11-41
CONSOLIDATED AIRCRAFT CORP
DEFENSE PLANT CORP. PLAN
COR-20-VERTICAL.

Plant II Construction Progress. First structural steel erected. 11 April 1941.

15901 5-5-41
CONSOLIDATED AIRCRAFT CORP
DEFENSE PLANT CORP. PLAN
COR-20-VERTICAL.

Plant II Construction Progress. Roof over half of first building. 5 May 1941.

15946 7-2-41
CONSOLIDATED AIRCRAFT CORP
DEFENSE PLANT CORP-PLAN
COR-20-VERTICAL.

Plant II Construction Progress. Roof over two main buildings.
2 July 1941.

15968 8-20-41
CONSOLIDATED AIRCRAFT CORP
DEFENSE PLANT CORP.
PLAN COR-20. VERTICAL.

Plant II Construction Progress. All buildings under roof. 20 August 1941.

Aerial Photo of Plant II Prior to Completion of truck overpass.

Photo taken 10 January, 1942

15829 2-22-41
CONSOLIDATED AIRCRAFT CORP
PARTS PLANT LOOKING NORTH.

Photo shows how flood waters, due to unusually heavy rains, halted construction of Plant II. 22 February 1941.


TASTE-RITE
BAR-B-Q
IT'S BETTER FOOD
TEXACO
WALTER CHURCH
TEXACO
Dr. Pepper
MILK
Spend YOUR VACATION
AT
LAKE LARSEN
BOATING · BATHING · FISHING!
Pacific Blvd. San Diego

2-22-4

Close-up of main street intersection shown in preceding photo. 22 February 1941.

Proposals, based on preliminary drawings and specifications, were received from several contractors. These proposals covered the complete project except for the fill and grading of the site. A separate contract was let for this work.

After the receipt of the general proposals and the award of the contract, it was decided to remove the fabricating and erecting of the structural steel from the general contract and handle this work under a separate agreement. The general contract was cost-plus-a-fixed-fee and the structural steel contract was on the basis of a price-per-ton.

Negotiations in connection with the financing of this expansion extended over a period of approximately two months. The entire plant was constructed and equipped under a Navy sponsored R.F.C. Lease Agreement. It is significant to observe here that during the summer of 1940, the entire San Diego facilities of Consolidated were allocated to the Navy for administration and control, by mutual agreement of the two military services.

During the entire construction program building materials of all kinds were becoming more and more difficult to obtain. In an attempt to control the use of these materials, priorities were first assigned in the early part of 1941. It is not felt, however, that priorities accelerated the delivery of construction materials although the system undoubtedly did assist in procuring certain materials which otherwise would not have been available.

There were two main causes of construction delay in this program; (1) inclement weather, and (2) late deliveries of fabricated structural steel.

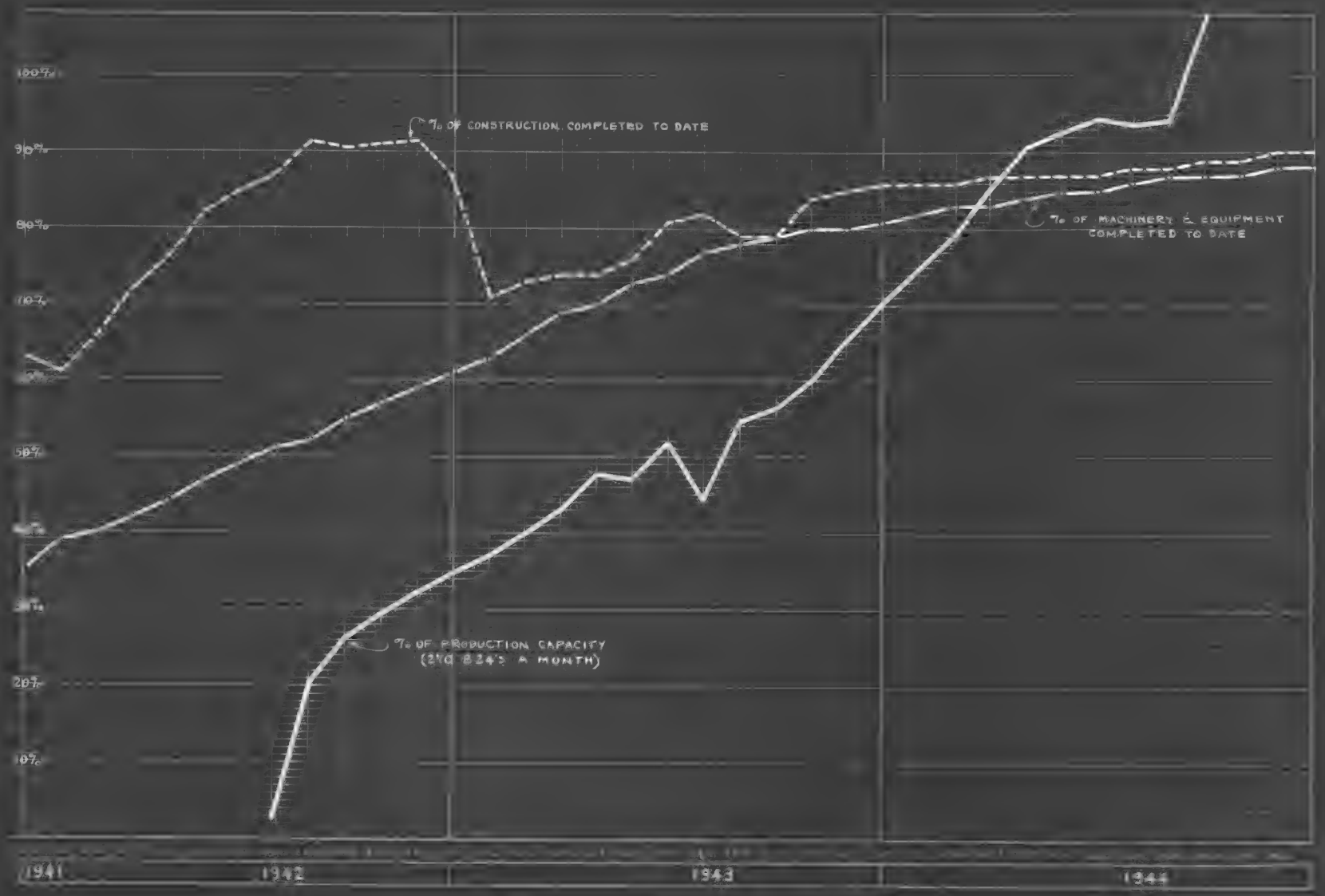
The first delay was caused by the extremely heavy rainfall recorded in the spring of 1941, which converted the plant site and surrounding area into a lake two feet deep. The second delay was caused by the local structural steel contractor placing an order for steel with a Pittsburgh mill whose schedules were crowded and who apparently favored eastern over western business, consequently slighting the latter in the matter of deliveries. It was eventually necessary to send an expeditor back to the mill and keep him there until all the steel had been shipped.

Buildings were occupied as rapidly as construction operations permitted and a minimum use made of temporary facilities. It is noted, however, that a large hydropress was placed in operation before completion of the building by the erection of a local temporary housing. Throughout the war period an important though never large part of operations had to be done under temporary canvas shelters.

This expansion increased the area of the San Diego facilities by 1,700,000 sq. ft. at a cost of approximately $11,000,000.

CONSOLIDATED VULTEE AIRCRAFT CORP
SAN DIEGO DIVISION

PERCENTAGE COMPARISON - CONSTRUCTION - MACHINERY & EQUIPMENT ACCEPTANCES



CONSTRUCTION AND MACHINERY

Date	(in 000) Total Authorization (1)	(in 000) Bldg. Constr. Authorized (2)	(in 000) Machy. & Eqipmt. Authorized (3)	Construction: Amount Committed as % of Amount Authized (4)	Construction: Completed as % of Amount Committed (5)	Construction: Completed as % of Amount Authized (6)	Machinery and Equipment: Completed as % of final Total Amt Authized (7)	Machinery and Equipment: Ordered as % of Amount Authzd. (8)	Machinery and Equipment: Delvd. as % of Amount Ordered (9)	Machinery and Equipment: Delvd. as % of Amount Authzd. (10)	Machinery and Equipment: Delvd. as % of final Total Authzd. (11)
Prior	19,129	11,268	7,861	75	67	50	22	90	77	68	31
June 41	19,140	11,269	7,871	75	84	63	28	90	85	76	35
July	23,818	13,444	10,374	72	85	61	32	76	84	64	39
Aug.	24,631	13,455	11,176	78	85	66	35	76	81	61	40
Sept.	24,651	13,471	11,180	80	89	72	38	78	83	65	42
Oct.	24,673	13,491	11,182	83	91	76	41	79	86	68	44
Nov.	26,962	15,517	11,445	85	97	82	51	82	86	71	47
Dec.	26,962	15,517	11,445	87	97	85	52	85	87	74	49
Jan. 42	26,969	15,523	11,446	90	96	87	53	87	88	76	51
Feb.	26,981	15,523	11,458	94	99	93	57	88	89	79	52
Mar.	27,696	16,190	11,506	95	96	91	58	91	91	82	55
Apr.	27,736	16,203	11,533	95	97	92	59	95	90	85	57
May	27,755	16,212	11,543	95	97	93	59	98	89	96	59
June	32,597	17,424	15,173	90	96	87	60	82	84	69	61
July	37,698	22,445	15,253	80	89	71	63	82	87	71	63
Aug.	37,746	22,458	15,288	82	89	73	65	85	87	74	66
Sept.	37,946	22,458	15,488	82	90	74	66	87	87	76	69
Oct.	38,167	22,648	15,519	87	85	74	67	87	89	78	70
Nov.	37,600	22,070	15,530	89	86	76	67	88	92	81	73
Dec.	37,611	22,070	15,541	95	85	81	71	88	93	82	74
Jan. 43	37,703	22,121	15,582	95	86	82	72	88	96	85	77
Feb.	38,753	23,171	15,582	95	83	79	72	89	97	86	78
Mar.	39,133	23,233	15,900	95	83	79	73	90	95	85	79
Apr.	39,484	23,397	16,087	95	88	84	78	91	94	85	80
May	39,684	23,427	16,257	95	89	85	79	91	93	85	80
June	39,999	23,689	16,310	95	91	86	81	93	92	86	81
July	40,326	23,950	16,376	95	91	86	82	93	92	86	82
Aug.	40,690	24,144	16,546	95	91	86	83	96	89	86	83
Sept.	40,888	24,169	16,719	95	91	87	83	96	89	86	83
Oct.	41,054	24,169	16,885	95	92	87	84	97	88	85	84
Nov.	41,110	24,169	16,941	95	92	87	84	97	89	86	85
Dec.	41,677	24,788	16,889	95	92	87	86	98	88	87	85
Jan. 44	41,803	24,788	17,015	95	93	88	86	98	89	87	86
Feb.	41,997	24,964	17,033	95	93	88	87	98	89	88	87
Mar.	42,025	24,964	17,061	95	93	89	88	98	90	88	87
Apr.	42,083	25,022	17,061	95	93	89	88	98	90	88	87
May	42,250	25,091	17,159	95	94	90	89	98	90	88	88
June	42,415	25,231	17,184	95	94	90	90	98	90	88	8

Columns 4 and 8 are merely estimates which are used to indicate a trend, rather than to show exact values.

Additional Expansions:

In addition to the major expansion programs there were smaller expansions continually in progress. An administrative office building, company financed, was started in April 1942 but due to a four months delay in steel deliveries and additional delays in other critical materials, it was not completed until March of 1943. This building was a seven story, reinforced concrete structure, 140' x 140', with a basement and an executive dining room penthouse on the roof. This building was designed and built without windows, used fluorescent lighting throughout, and for an air cooling system utilized what is said to be the largest steam-jet air conditioning unit in the country. This building had a floor area of approximately 157,000 sq. ft. and cost $1,300,000.

In the spring of 1943 a Navy sponsored Emergency Plant Facilities expansion was accomplished which was large in dollar volume ($3,000,000) but small in added area. The expansion was mainly machinery and sprinkler equipment with only a few thousand square feet added in the way of sheds, mezzanines, and small additions to existing working spaces.

Beginning in the spring of 1944 and finishing a year later, Consolidated, along with the City of San Diego and the Marine Base, improved the existing facilities at Lindbergh Field and increased the length of the main runway to 8000 feet. This was done at a combined total cost of approximately $3,000,000, largely company financed.

In the meanwhile, additional Plant #2 expansions were being accomplished in the way of miscellaneous buildings, manufacturing and service and storage areas, amounting to 176,000 sq. ft. This brought the Plant #2 area up to 1,876,215 sq. ft. which added to the Plant #1 area of 2,303,469 sq. ft. resulted in a total area at San Diego of 4,179,711 sq. ft.

ANALYSIS OF PRODUCTION ACCELERATION

Summary:

Based on careful comparison of monthly performance against Army requirements as reflected in the several schedules and contracts as they were released, the Contractor's production acceleration is rated as superior. While the first airplane was flown in the fall of 1939, passed its 629 inspection in February and was formally accepted by the Army in August both of 1940, this was the prototype airplane and represents only a small portion of the engineering program. The schedule of 30 November 1940 called for only seven airplanes in June of 1941, peaking with thirty five airplanes in February of 1942. It was not until 20 May 1941 that anything like war production quantities first became visible, and this was only one hundred airplanes

per month, which was promptly cut to ninety per month. In March of 1942 requirements for April of 1943 were set at 136 airplanes, which was raised in August by Navy requirements to 156 airplanes. The W-8 schedule with an effective date of 18 October 1943 is the first which actually schedules the peak production reached less than a year later. It should be noted that in the first peak month 47 airplanes of three other types were being accepted by the Navy, while the Army accepted 270 B-24's.

In view of the combination in the one plant of the development engineering and the production development, coupled with the frequent releases of small increments of increased requirement, it is now impossible to fix the point of approval by the Army of the full scale production project as clearly as in the case of an associate prime contractor who gets a contract and some sort of an engineering-production package. Actually the two phases of development overlapped and it was not until October of 1943 that the final release came, at which time planning for the ultimate peak virtually had been completed.

One point is clearly established however. In spite of the contractor's constant effort to play safe as he saw the picture day by day, the slope of each of the acceleration curves, whatever the scheduled volume, was just a little too steep in the early months. Neither the Contractor nor the Army knew, and the schedule curves did not reflect the actual point at which the project was located on the learner's curve.

Production Plan:

As the war clouds gathered, and with the concrete and priceless assistance of the French contract, later taken over by the British, the company constantly worked for more and more heavy bomber productive capacity. Such as they were, these general plans covered -

1. In such volume as was stated in the ever changing requirements, the complete airplane was to be built on site, and with an insignificant amount of subcontract assistance. Facility expansion was geared directly to this policy.

2. Labor, material, equipment, etc., were all to be available in slightly larger quantities than the anticipated needs.

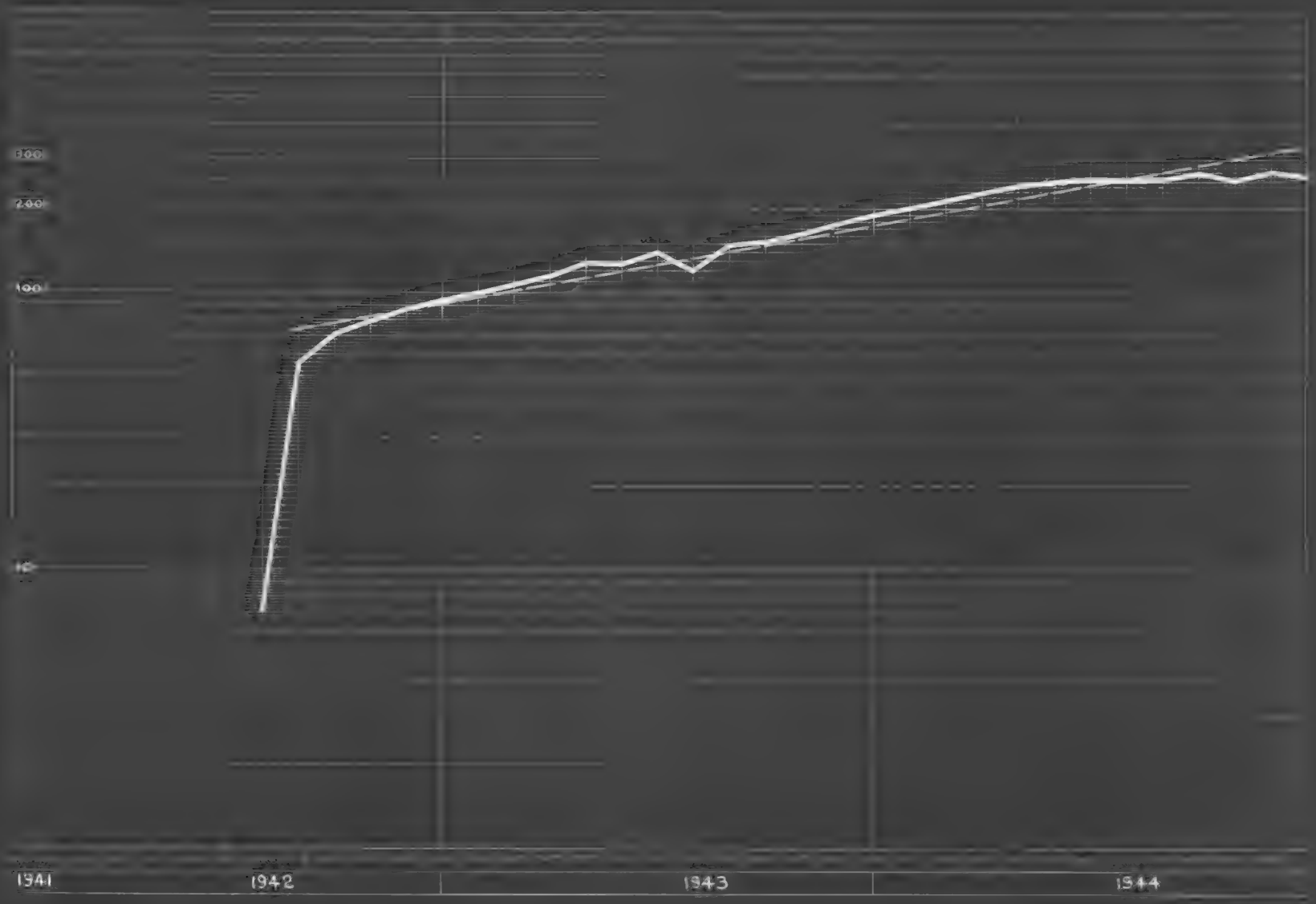
3. Methods were to be those successfully used in building flying boats for the Navy.

4. Equipment was in the first instance to be that used previously and already installed, supplemented by more of the same type.

5. Manpower in the plant was to be that native to the community. No studies were made or could be made to show that the ultimate load would exhaust not only the local market, but also overtax the practical possibilities of importation.

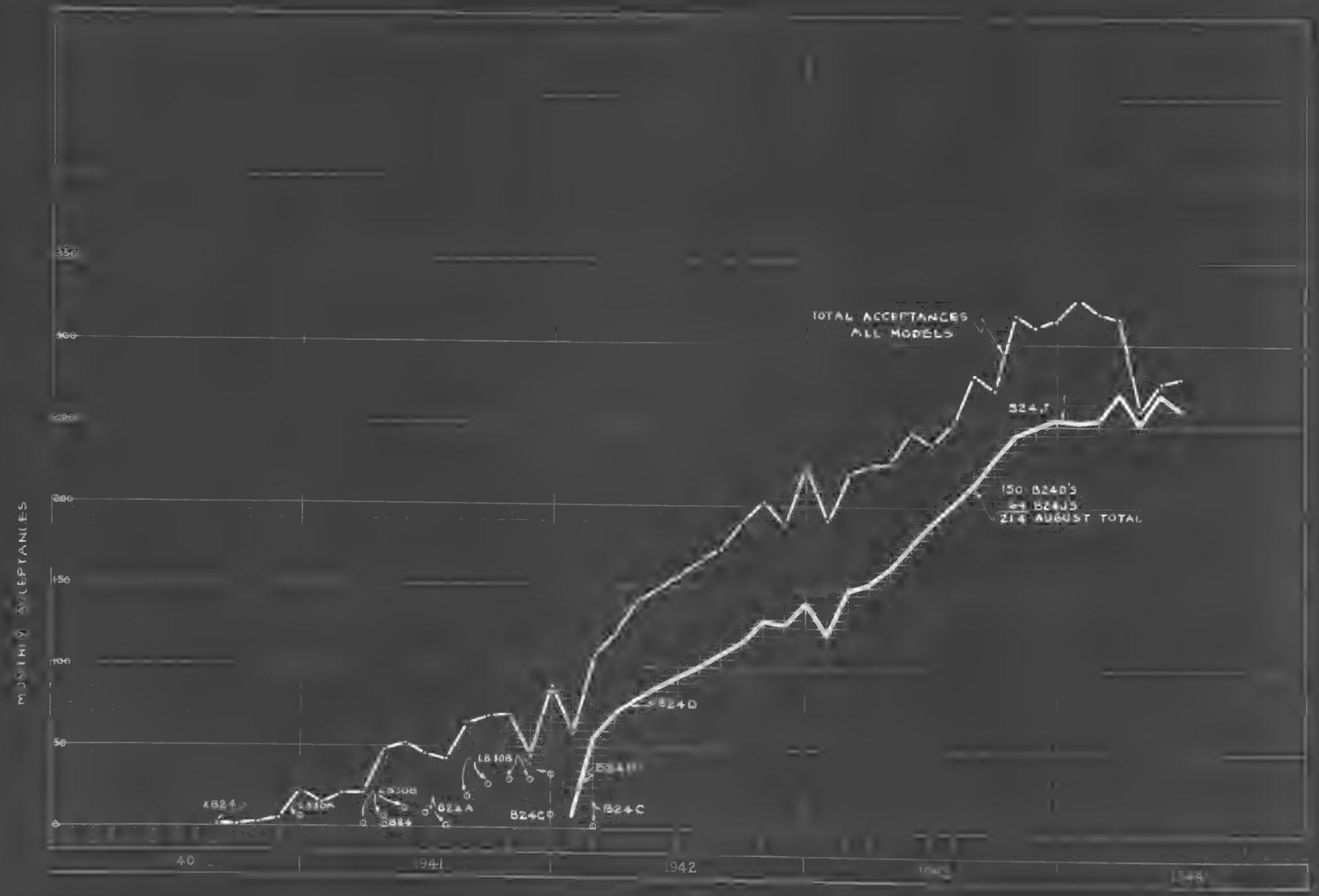
CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

B-24 MONTHLY ACCEPTANCES



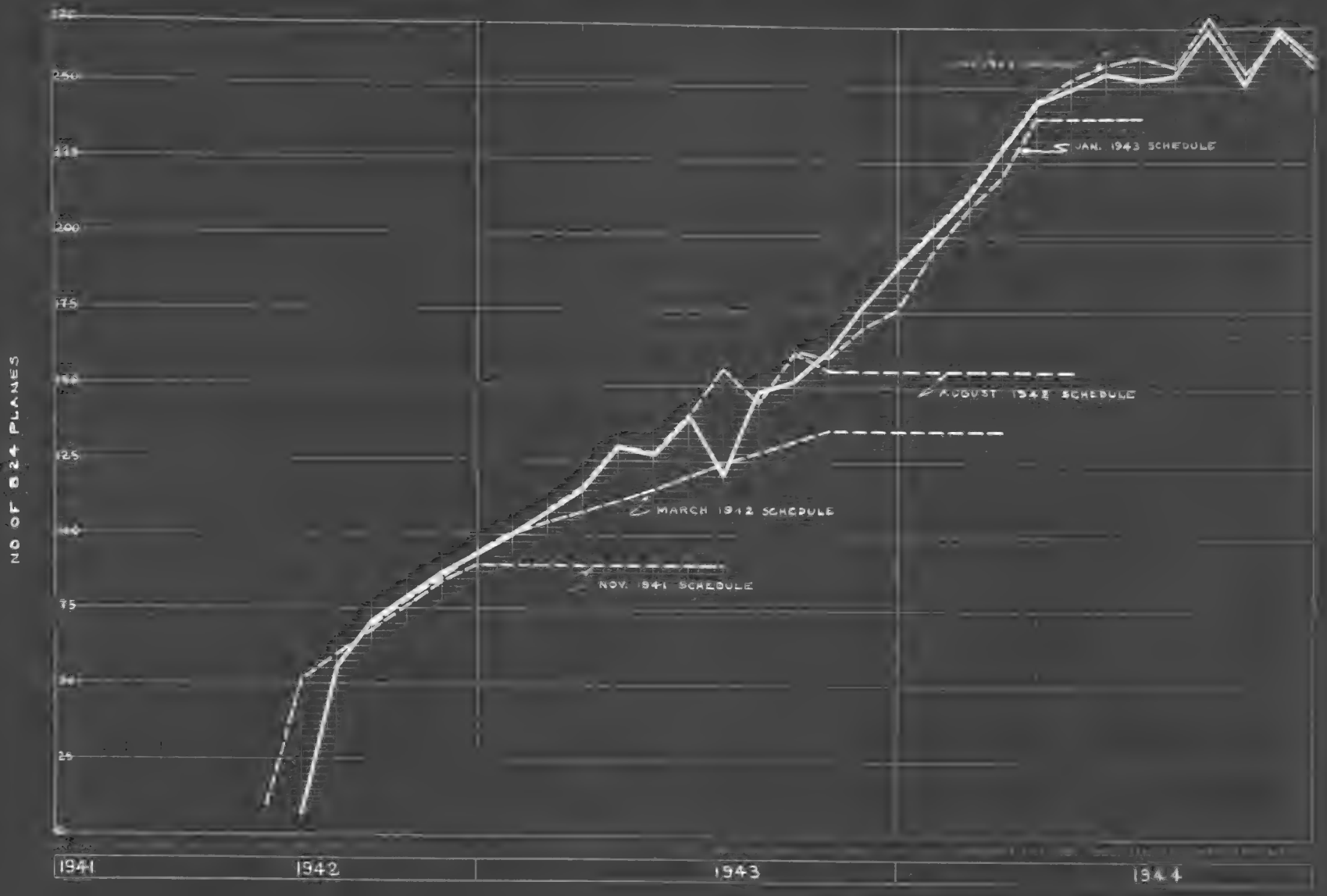
CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

AIRPLANE ACCEPTANCES
ALL MODELS



CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

B24 SCHEDULES AND ACCEPTANCES



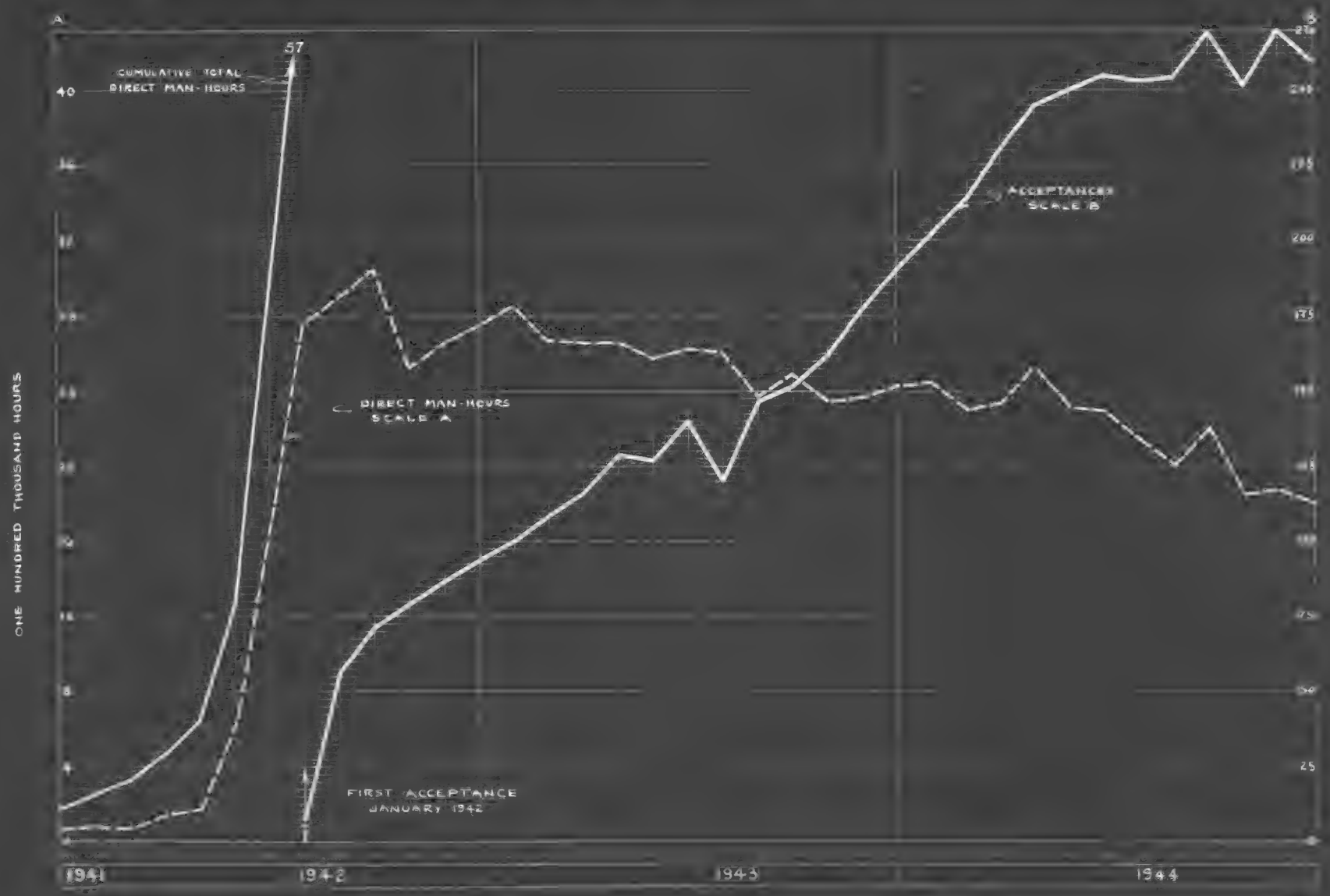
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION

B-24 Acceptances and Schedules

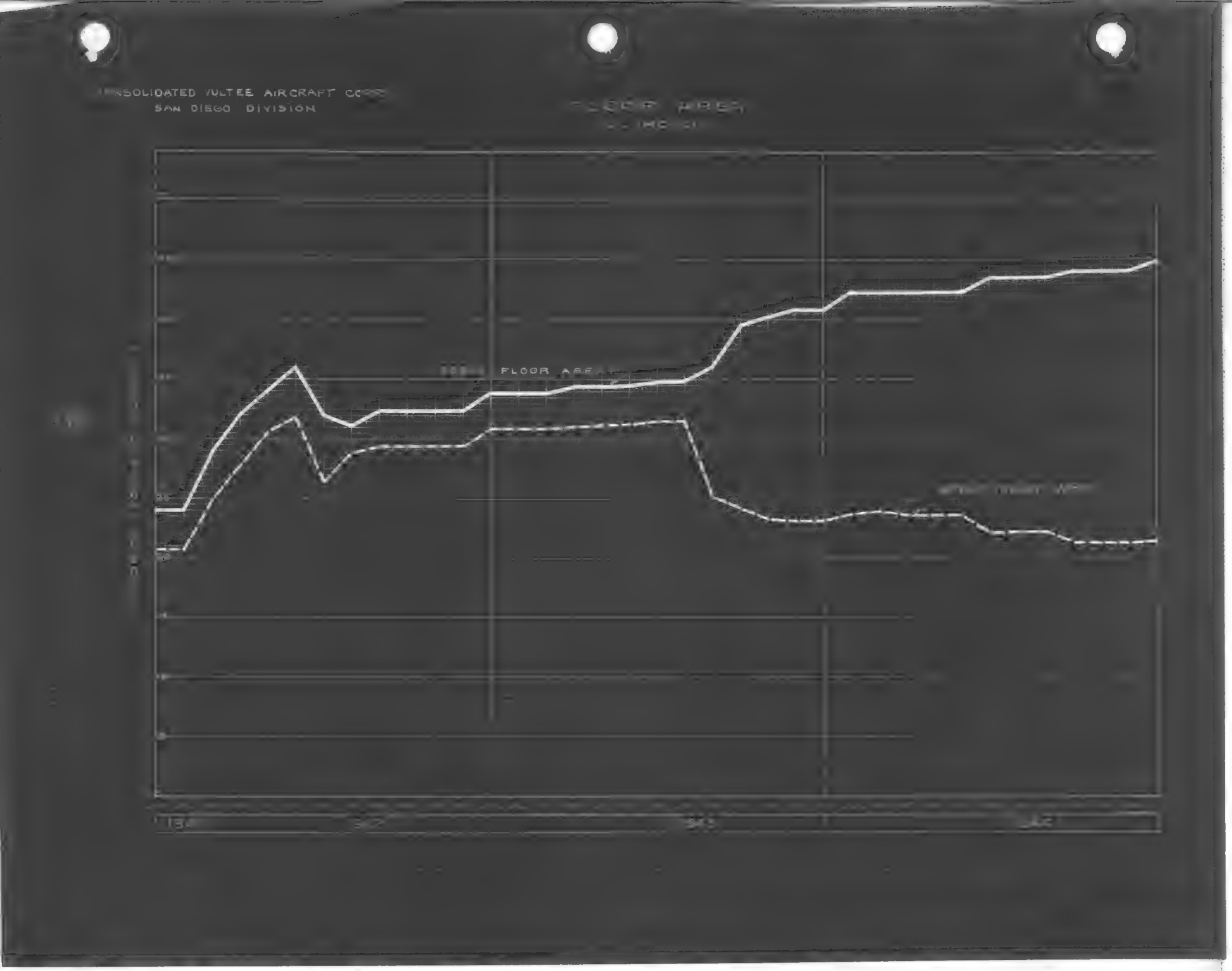
	Accept-ances	Schedules				
		Nov.'41	March'42	Aug.'42	Jan.'43	June'43
Jan. 42	7	52	7			
Feb.	56	60	56			
Mar.	71	68	70			
Apr.	79	76	78			
May	87	84	86			
June	94	90	94			
July	100	90	100			
Aug.	108	90	104	108		
Sept.	116	90	108	116		
Oct.	129	90	112	129		
Nov.	127	90	116	127		
Dec.	140	90	120	140		
Jan. 43	120	90	124	156	156	
Feb.	148	65	128	144	144	
Mar.	152		132	162	162	
Apr.	162		136	156	160	
May	177		136	156	170	
June	190		136	156	176	190
July	202		136	156	195	202
Aug.	214		136	156	210	214
Sept.	230		136	156	221	230
Oct.	245		86	156	240	245
Nov.	250			156	240	253
Dec.	255			142	240	258
Jan. 44	253				240	261
Feb.	254				198	257
Mar.	270					275
Apr.	251					255
May	270					268
June	260					257

CONSOLIDATED VULTEE AIRCRAFT CORP
SAN DIEGO DIVISION

B24D ACCEPTANCES AND DIRECT MAN-HOURS

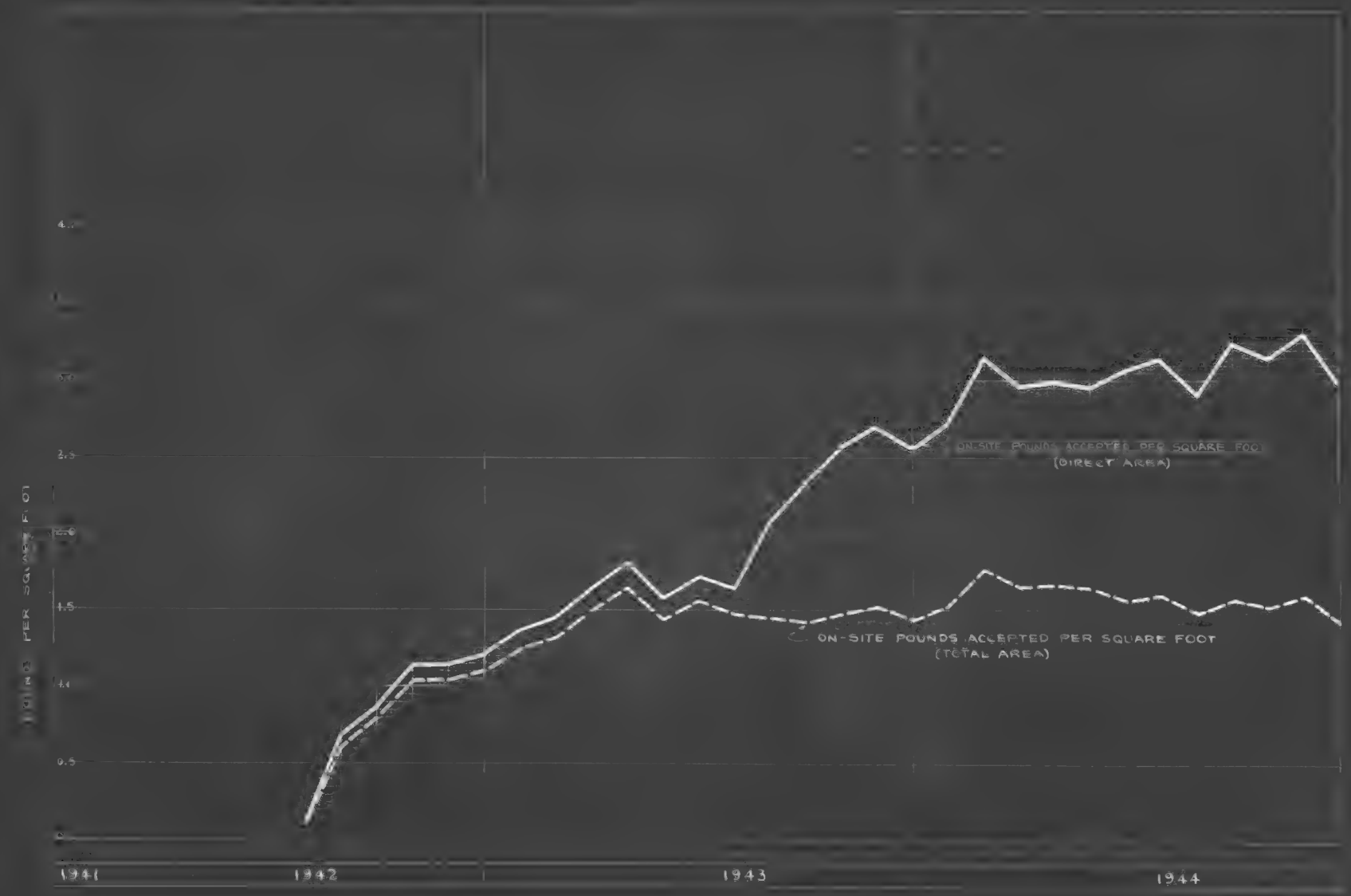


CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION



NSOLIDATED VULTEE AIRCRAFT CORP.
AN DIEGO DIVISION

B24 POUNDS ACCEPTED PER SQUARE FOOT



CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION

AREA UTILIZATION & OUTPUT

	Total Floor Area	Direct Floor Area Direct Total	Direct Floor Area Direct % Total	Direct Floor Area Acre	Exp. & Non-Acre	Direct Yard Area	Work Week Direct Workers	Work Week Actual	Work Week Schedule	Work Week Absence Rate	No. of Accept.	Total Pounds Accepted			On Site Lbs. Acc.	Direct Man Hrs. per Direct	Total Sq.Ft. per Total	Direct Sq.Ft. per Direct	On Site Lbs. Acc. per Sq.Ft. Total Area	On Site Lbs. Acc. per Sq.Ft. Direct Area	%	Comp
June 41	48	41	86	39	2	4	289	46.5	50	3.24	--	--	--	--	--	1.43	139	169	--	--	--	--
July	53	45	86	43	2	4	402	41.1	50	3.13	--	--	--	--	--	1.73	120	144	--	--	--	--
Aug.	70	60	86	58	2	5	383	41.6	50	3.09	--	--	--	--	--	1.27	122	147	--	--	--	--
Sept.	122	106	87	103	3	9	718	41.3	50	3.30	--	--	--	--	--	1.36	118	126	--	--	--	--
Oct.	139	125	90	121	4	9	859	48.9	50	2.99	--	--	--	--	--	1.38	119	129	--	--	--	--
Nov.	468	414	88	402	12	30	3,164	45.7	45	2.80	--	--	--	--	--	1.52	118	153	--	--	--	--
Dec.	1,053	870	83	839	31	76	8,421	45.7	45	3.30	--	--	--	--	--	1.93	94	109	--	--	--	--
Jan. 42	1,388	1,290	93	1,241	49	103	13,811	51.2	53	5.41	7	141	33	174	146	2.14	81	110	.11	.11	16.0	84.0
Feb.	1,705	1,551	87	1,493	58	121	14,510	53.8	53	5.83	56	1,130	136	1,266	1,063	1.87	81	109	.62	.69	16.0	84.0
Mar.	1,653	1,504	91	1,448	56	120	15,233	45.3	48	5.58	71	1,432	133	1,565	1,315	2.03	81	110	.80	.87	16.0	84.0
Apr.	1,543	1,404	91	1,352	52	110	12,620	46.3	48	4.71	79	1,594	311	1,905	1,600	1.80	79	112	1.04	1.14	16.0	84.0
May	1,614	1,469	91	1,390	79	115	13,239	48.8	48	4.43	87	1,755	244	1,999	1,679	1.81	76	107	1.04	1.14	16.0	84.0
June	1,630	1,486	91	1,414	72	1,236	13,768	45.6	48	4.64	94	1,896	239	2,135	1,793	1.85	75	106	1.10	1.21	16.0	84.0
July	1,619	1,477	91	1,405	72	1,228	14,263	48.5	48	4.65	100	2,017	385	2,402	2,018	1.93	75	108	1.25	1.37	16.0	84.0
Aug.	1,619	1,477	91	1,393	84	1,228	13,380	46.7	48	5.20	108	2,178	370	2,548	2,140	1.81	76	112	1.32	1.45	16.0	84.0
Sept.	1,707	1,546	91	1,459	87	1,347	13,301	48.6	48	5.39	116	2,340	686	3,026	2,542	1.72	78	125	1.49	1.64	16.0	84.0
Oct.	1,708	1,549	91	1,462	87	1,347	13,348	49.3	48	6.93	129	2,602	749	3,351	2,815	1.72	78	128	1.65	1.82	16.0	84.0
Nov.	1,763	1,599	91	1,510	89	1,382	12,810	55.6	48	7.02	127	2,562	451	3,013	2,531	1.61	76	131	1.44	1.58	16.0	84.0
Dec.	1,688	1,530	91	1,438	92	1,472	13,113	56.2	48	6.81	140	2,824	604	3,428	2,633	1.72	78	132	1.56	1.72	23.2	76.8
Jan. 43	1,897	1,719	91	1,616	103	1,654	13,809	50.3	48	5.31	120	2,778	895	3,673	2,814	1.52	78	124	1.48	1.64	23.4	76.6
Feb.	1,953	1,364	70	1,305	59	848	13,732	47.6	48	4.95	148	3,426	610	4,036	2,837	1.73	80	99	1.45	2.08	29.7	70.3
Mar.	2,074	1,269	61	1,212	57	821	13,261	48.8	48	4.75	152	3,530	801	4,331	2,954	1.96	88	96	1.42	2.33	31.8	68.2
Apr.	2,186	1,283	58	1,204	59	480	13,449	46.2	48	4.91	162	3,763	745	4,508	3,241	1.86	91	95	1.48	2.57	28.1	71.9
May	2,334	1,318	56	1,256	62	423	13,733	46.3	48	5.48	177	4,111	929	5,040	3,548	1.80	94	96	1.52	2.69	29.6	70.4
June	2,452	1,385	56	1,320	65	444	13,832	40.4	48	5.60	190	4,481	695	5,176	3,535	1.76	97	100	1.44	2.55	31.7	68.3
July	2,531	1,421	56	1,356	65	444	12,971	41.5	48	6.07	202	4,764	981	5,745	3,849	1.72	105	110	1.52	2.71	33.0	67.0
Aug.	2,551	1,437	56	1,372	65	444	12,425	43.2	48	6.22	214	5,047	1,110	6,157	4,525	1.59	107	117	1.77	3.15	26.5	73.5
Sept.	2,697	1,507	56	1,439	68	473	12,737	40.9	48	6.79	230	5,354	803	6,157	4,464	1.56	109	118	1.66	2.96	27.5	72.5
Oct.	2,790	1,559	56	1,489	70	489	13,090	43.7	48	4.72	245	5,703	684	6,387	4,663	1.62	109	120	1.67	2.99	27.0	73.0
Nov.	2,773	1,549	56	1,479	70	486	12,821	43.3	48	5.00	250	5,820	873	6,693	4,571	1.49	108	121	1.65	2.95	31.7	68.3
Dec.	2,856	1,456	51	1,388	68	456	12,398	40.5	48	8.02	255	5,897	767	6,664	4,465	1.58	112	121	1.56	3.07	33.0	67.0
Jan. 44	2,704	1,379	51	1,314	65	432	11,544	41.0	48	6.27	253	5,850	819	6,669	4,335	1.55	113	118	1.60	3.14	35.0	65.0
Feb.	2,699	1,376	51	1,311	65	432	11,417	42.8	48	5.52	254	5,873	587	6,460	4,005	1.46	116	121	1.48	2.91	38.0	62.0
Mar.	2,987	1,443	48	1,368	75	463	11,696	41.8	48	5.50	270	6,196	1,239	7,435	4,684	1.53	128	123	1.57	3.25	37.0	63.0
Apr.	3,048	1,473	48	1,396	77	473	11,066	40.6	48	5.20	251	5,760	1,411	7,171	4,625	1.26	133	138	1.52	3.14	35.5	64.5
May	2,960	1,431	48	1,356	75	459	9,687	41.4	48	5.44	270	6,196	1,097	7,293	4,740	1.31	142	148	1.60	3.31	35.0	65.0
June	3,098	1,480	48	1,405	75	480	9,085	43.7	48	5.31	260	5,983	933	6,916	4,426	1.22	144	163	1.43	2.99	36.0	64.0

6. No changes in management, procurement, or other functions or controls were made, contemplated, or appeared necessary.

The production control organization for example was not set up until March 1941. It was charged with carrying through from master planning, detailed scheduling, order writing, dispatching, to stock control and issue of all finished parts and assemblies to the line, and parts or assemblies to Spare Parts. At the peak this outfit employed 2500 people.

The impact of the Ford Willow Run project, approved 25 February 1941, proved a heavy overload on the already strained organization, and definitely set back operations at San Diego. The company learned much from Ford that proved helpful in later months, but it certainly got nothing by way of assistance in production planning from the automobile men at this crucial stage. While deliveries were made during 1939, 1940, 1941 and 1942 of B-24 type bombers, and the contractor was pretty much in line with Army expressed requirements, it must be kept in mind that these airplanes were built, not manufactured. They were built not as the result of comprehensive industrial planning as it was then known outside of the aircraft field, but because men knew how to build the "hard way" and because they had the determination to keep on doing more and more of such building. All of which reflects very greatly to their credit and to that of the contractor, and made a material contribution to the early development of American air power.

During the summer of 1941 it became necessary to break down the airplane so that more and more people per hour could be put on assembly operations, and at the same time subcontracting and feeder plant operations gradually took more and more load off site. It took over a year for the new production control organization and the magnitude of the actual load to make any real imprint on the acts of the company. But by the summer of 1942 the moving assembly lines, complete break down in subassemblies, subcontracting operations, and the use of company owned feeder plants began to tie together into the first clear outline of the final preparations to actually manufacture.

The following serious, insurmountable obstacles had been encountered as the months passed, making earlier achievement of this objective impossible:

1. The rate and quantity of B-24 airplane requirements were constantly being changed by Army - perhaps from necessity.

2. The Contractor was completely lacking in production experience.

3. The airplane was not, and at that time could not have been, designed for volume production. No one then knew how to even approach such an end.

4. The Willow Run project continually demanded the attention of San Diego management, taking time which was never available.

5. The Contractor's engineering policy which had been so satisfactory in building airplanes by hand methods through the peacetime years was not only not helpful in preparation for production but frequently actually interfered as one detail after another designed in the shop instead of on the drawing board failed to meet in the jigs.

6. The engineering changes which the Army required to be made in this peacetime airplane doubled the load on tool design, tool making, production planning and the procurement of materials. The vital necessity of many of these early as well as many of the later changes in the airplane is definitely challenged.

7. The building of the tooling was constantly kept in check by the non-availability of mechanics and engineers in the San Diego area, and the constant lack of living accommodations for those who might otherwise have been moved in. Had other functions proceeded more rapidly, tooling certainly would have stopped the acceleration, or forced a major change in the established policy of producing tooling on site.

8. In general, while the airplane was designed, the plant built, and the shop equipment procured in peacetime, the organization found itself lacking in experience and power to deal more effectively with the rapidly changing war obstacles, with the result that the recorded result literally was all the production obtainable, and actually was a notable achievement for that organization at that point in its growth.

Period of Acceleration:

As shown by the record alone, acceleration actually began in the summer of 1941 and the curve is relatively smooth from that point to peak. Prior to 1942 facilities had been developed, the growing organization was "shaking down", and the Army and the company were beginning to acquire a mental picture of the airplane itself and a mutual understanding of the size of the job. But, airplanes in war quantities were not and could not be delivered.

Manpower had become critical, and the unplanned policy of taking the work to the worker had become an enforced practice. Subcontracting and feeder plant operations had become major factors by the end of 1942. Recruiting, training and the practice of applying new people to the line had all been overhauled from necessity, and improved. Housing projects were in the making, but never became adequate until terminations cut the requirements.

During 1942 the merger with Vultee was developing and was legally completed by March of 1943. The absorption of personnel and adjustments in operating methods strengthened the company as a whole. Of especial importance to the B-24 project, the San Diego Division, consisting chiefly of the personnel which had brought the B-24 to this point, was established, and charged with the responsibility of finishing the job. The Division Manager for example had several superiors and several titles during the "shake down" period but kept the job going at ever increasing rate. Functions, sections and departments were shifted, strengthened or supplemented, but none of the changes appear to have been required by major failures or to have resulted from the "reorganization" found in many other programs during the war. Rather they appear to have been caused by the compression into a score of months of those growing pains, over-emphasized by the abnormal conditions, which are normally spread over a full generation of corporate life and growth.

A break in the curve occurred in 1941-42 resulting from ambitious acceptance of schedules accelerating deliveries too rapidly for the assimilation of the necessary general experience. Of similar character but somewhat more specific was the break in 1942-43 due to failure to properly evaluate the time cost of the major engineering changes then in process.

Major elements of strength were developed during this long period of evolution which clearly would have made possible the delivery of many more airplanes per day from the San Diego Division had they been required and planned. This fund of experience has already begun to waste away in the backwash of terminations, although it comprises that indefinite intangible asset to national security which must be conserved and preserved at any and all costs. Important elements were:

a. The development of a very satisfactory system of rewarding management of all echelons by the monthly payment to each man of an incentive bonus, carefully measured and clearly understood.

b. The development of an ingenious and highly effective subcontract control system based on the supply of all necessary technical assistance at the proper time, and the application of the learner's curve to each subcontract.

c. The development of the feeder plant system, including its own warehouse for materials and its own internal controls as a part of the on-site manufacturing department. Both of these methods of taking the work to the worker paid off in terms of employee morale and efficiency, both being substantially higher and the cost being substantially lower than ever could be reached in the over-congested conditions in and around the main plant.

d. The steadily improving position of the airplane, management personnel, and the direct workers on the learner's curve. Four years of growth from the date of birth of the airplane had produced an immense amount of experience which at last began to appear in operations and in deliveries. Of the three, management know-how was by far the most important, although transfer of the difficult, and the termination of the totally inept direct worker, was rapidly increasing the average value of the working force.

Careful studies of the net worth of the contractor in terms of experience, and the recommendations which he makes for the establishment of ideal conditions within and without the company under which this particular job would be done in mobilizing for the next war, thoroughly justify his estimate of 12 to 18 months time to accelerate to a peak production of 270 B-24 airplanes per month.

Engineering Changes:

It is difficult indeed for professional production engineers to discuss acceleration of "production" relative to an article consisting of over 45,000 parts, of which only 6,725 articles were produced while 1820 changes were being made. This is an average of three point six airplanes per change, or some three changes per day average at peak production. In an article as structurally complicated as an airplane, with such a high degree of interrelationship of parts, components and equipment, the engineering change program was far the largest single factor of influence on production acceleration. It was not disposed of in the engineering department as might be superficially assumed, but it ran through every department of the plant imposing on each roughly the same heavy overload. Attention is also invited to the frequent and radical changes in the priority ratings of the changes which had been ordered, as illustrated by plotting the status of ten changes on Chart #8.

The challenge to the soundness of the engineering change program as a whole and the recommendations for a radical change in it must be taken with all seriousness when it is realized that 80% of the going cost of the Tooling Department went into changes in tooling and only 20% into maintenance, while for every person engaged

in procuring materials for the production program, one other person was engaged in changing material procurement and delivering new materials to the line.

Methods & Tooling:

Originally seven designers and seventy one tool makers were engaged in producing the assembly jigs and the hand tools customarily used in pre-war airplane plants. As production requirements grew, necessitating more and more complete breakdown of the airplane to smaller subassembly units, so the demands increased for more tooling - more tools, more rigid and more precise, and so the personnel increased to a peak of 584 on methods and tool design plus 146 on lofting, and 1420 toolmakers. This was indeed an accomplishment in a pre-war community totally lacking in precision metal working industry.

In addition to manpower the tooling program faced two other serious obstacles - engineering and know-how. The engineering of the plane, due partly to its peacetime conception and design and partly to the continuous stream of Army changes, was never current. This resulted in a continuing demand for tools to be delivered yesterday - and in many cases they were made before the drawings were finished. As for changes, attention must be again called to the distribution of the tooling expense dollar at the time of peak production - 20¢ for maintenance and 80¢ for changes for various reasons of which only a quarter was due to improved methods.

Know-how was not. There never had been comparable volume of production of airplanes or any similar article so experience had to be acquired along the road. The first set of tools was satisfactory when used as intended to build a few airplanes, largely by hand. But these tools failed completely to produce assemblies which would "drop into place." And it proved to be impossible to get or keep the light tools lined up so exact duplicates could be made. The fixtures had to be completely rebuilt, much heavier.

The guage program had to be developed to assist quality control, including masters and control masters. This and the constant demand for more and duplicate tools brought out one of the outstanding contributions of the contractor - the tooling dock as it is called. This super master control fixture bears somewhat the same relationship to the production development of airplanes as the large wind tunnel does to their engineering development.

Materials:

"It was necessary to completely revise the pre-war conception of purchasing" and the evolution produced a stream-lined department which cut overall inventory from an early figure of thirty-one million dollars to eighteen million dollars, cut flow time in half,

and prevented line stoppages due to material shortages. The evolution developed a new material system and the management incentive bonus system which established direct financial profit to the individual for good operation and penalties for failures.

The resulting material system was simple. By classes of items procured and stocked, the department was broken into eight complete sections. Each section chief was responsible for adequate purchasing, proper stockage, and timely delivery to the line of all items in the class - in effect there were eight parallel and complete material departments. This is held to be a new and different organizational approach to a complicated problem of this nature, and one which made a material contribution to the production record established.

The major difficulty in the Material Department was the Engineering Change Program and the resulting continuing short procurement of critical electrical and hydraulic valves, fittings and accessories, and aluminum forgings and extrusions, all with long flow times even under normal uninterrupted procurement.

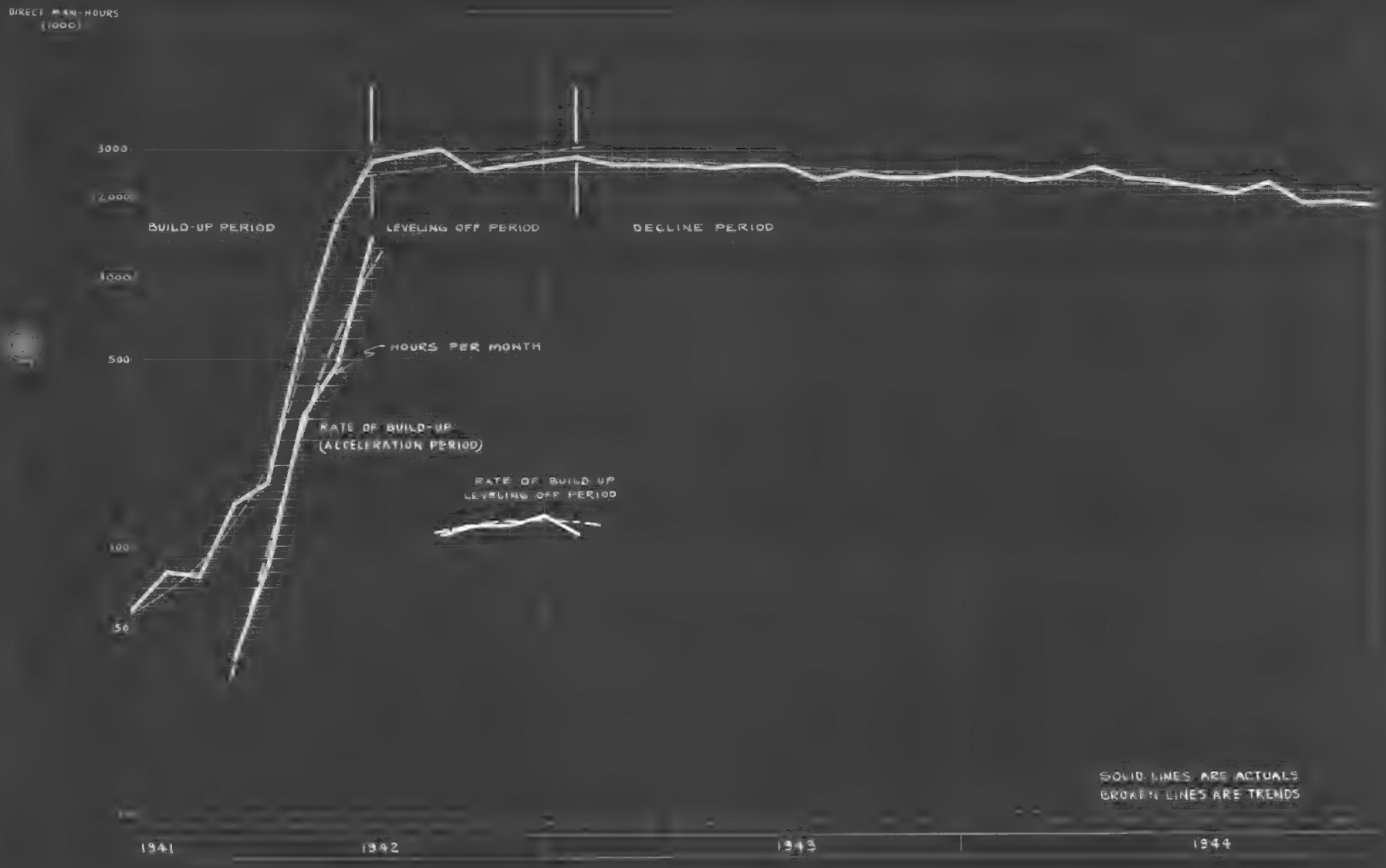
Manpower:

In hiring more people at peak than the total increase in the number of those gainfully employed in San Diego, in employing nearly 20% of the pre-war population of the county, and in the absence of basic studies to show that the final manpower load would be far beyond the local market, the Personnel Group did a tremendous job. Through cooperation with all possible outside agencies such as local schools, colleges and universities, trade schools and Government agencies, and through their own efforts in the fields of training, selection, up-grading, promotion, and recruiting campaigns both local and national, and in the face of a continuous and growing shortage of living facilities, they succeeded in pouring personnel into the plant too fast for economical utilization but always with capacity to keep production accelerating.

In a naval base city of long standing and rapid war growth in which fishing, small boats and tourists were the principle industries, the impact of the aircraft war program was received with a community attitude definitely negative and verging on the hostile. Of the peak increase of 50% in county population nearly 80% was attributed to Consolidated, yet the turnover rate for two years around the peak period was only .4% higher than that for the industry - 7.8 against 7.4. In spite of the housing shortage and the community feeling for the in-migrants as evidenced for example by the refusal of the retail merchants to keep open evenings for off-shift shopping, the absentee rate was maintained at 5.5% against

CONSOLIDATED VULTEE AIRCRAFT CORP
SAN DIEGO DIVISION

BUILD-UP OF DIRECT MAN-HOURS (B24D)



CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION

FORM 78 F&S

B-24D Build-up of Direct Man Hours

	Direct Man-Hours (Actual) (1000)	Cumulative Man-Hours	Direct Man-Hours (From Curve)	Build-up Increment (From Curve)
June 41	58	169	57	
July	80	249	67	10
Aug.	77	326	86	9
Sept.	144	470	124	38
Oct.	172	642	210	86
Nov.	633	1,275	520	310
Dec.	1,684	2,959	1,500	480
Jan. 42	2,762	5,721	2,950	1,450
Feb.	2,902	8,623	2,510	
Mar.	3,047	11,670	2,620	110
Apr.	2,524	14,194	2,740	120
May	2,668	16,862	2,860	120
June	2,754	19,616	2,990	130
July	2,853	22,469	3,100	110
Aug.	2,676	25,145	2,810	
Sept.	2,660	27,805	2,760	
Oct.	2,669	30,474	2,710	
Nov.	2,580	33,054	2,690	
Dec.	2,633	35,687	2,630	
Jan. 43	2,617	38,304	2,590	
Feb.	2,362	40,666	2,550	
Mar.	2,488	43,154	2,500	
Apr.	2,349	45,503	2,480	
May	2,366	47,869	2,440	
June	2,433	50,302	2,400	
July	2,446	52,748	2,370	
Aug.	2,300	55,048	2,330	
Sept.	2,342	57,390	2,300	
Oct.	2,531	59,921	2,280	
Nov.	2,311	62,232	2,220	
Dec.	2,296	64,528	2,190	
Jan. 44	2,138	66,666	2,160	
Feb.	2,008	68,674	2,110	
Mar.	2,205	70,879	2,090	
Apr.	1,856	72,735	2,020	
May	1,879	74,614	1,900	
June	1,803	76,417	1,890	

an industry average of 6.5% for the two years around the peak production month. These figures coupled with the steady increase in deliveries point conclusively to the soundness of personnel and general management practices.

Production (deliveries) doubled from the date of the personnel peak in November 1942 (45,531 persons) to peak production employment in May 1944, at which time total employment was 31,113. This drop represents accurately progress of the company along the learners' curve for at peak the program of taking the work to the worker had taken off site something over 50% of the manhours, thus accounting for doubling the production.

At peak 50% of direct workers were female, with definite programs for and substantial utilization of marginal workers. Naval personnel, off duty, made another substantial contribution. But all the contributions of personnel of all types and ranks could not overcome the losses entailed in the operations of selective service and the constant if unrealized threat of the draft on this young company and its equally young but highly experienced workmen. This situation leads directly to the most important recommendation of the manpower people to establish a single control for both airplane requirements and manpower utilization for the next war.

Inspection:

Faced with an even more serious recruitment problem, this Section grew up to a peak ratio of one inspector to twelve direct workers. Careful selection, adequate training, up-grading and practically 100% on site inspection maintained required quality standards without seriously retarding flow of production materials, while a percentage check of incoming parts and components kept outside operations under control.

ENGINEERING

Summary:

As previously pointed out, the XB-24 airplane was first conceived in late 1938 and designed, built and flown during the year 1939, which is considered to be record time for a plane of this size. However, this speed resulted in engineering information being sadly lacking when production was begun, as a high degree of "shop engineering" prevailed which later proved to be a serious handicap and one of the contributing factors delaying all associate prime operations, as well as those of the prime contractor.

The Plan:

At the time engineering was started on the XB-24 airplane, Consolidated Engineering Department consisted of approximately 75 men operating all phases of this Department and was mainly concerned with the Navy Flying Boat contract (then starting production) and since the B-24 was to embody many of the characteristics of this boat, no great increase in the engineering staff was contemplated. However, the fall of 1939 brought with it a contract for the production of B-24's and management decided that the Engineering Department was entirely too small for the job ahead. A recruitment plan was formulated and put in operation in the spring and summer of 1940 to secure the necessary engineers. This recruitment proved a wise move, because as the LB-30 (British version of the B-24) was produced and used in the European theatre numerous changes were indicated both from the production and combat viewpoints. This coupled with the joint B-24 production program starting in 1941 with Ford, Douglas and North American participating, made it necessary to maintain a staff of competent engineering personnel of approximately 600 at peak in the middle of 1944. The many difficulties encountered in the endeavor to maintain the required personnel necessitated the expending of considerable time and effort. Among the problems encountered was the engineering employee turnover (approximately 75% per annum) attributable to inadequate housing, uncertainty relative to Selective Service policy, transportation difficulties, etc.

Initial Difficulties:

At the time the first production contract was started in early 1940, it was found that the airplane was by no means engineered from a production point of view. Therefore, the task of simplifying the production break-down was undertaken. This program threw a terrific load on the small engineering department, first, because of the great number of engineering changes required and secondly, because of the department's lack of experience in production designing. At approximately this same time, the AAF added to the load by their determination that later B-24 aircraft must be provided with turbo-supercharged power plants, leakproof tanks, and turrets.

The impact of the Army change program at this point both on engineering and production was softened by the diversion of 26 airplanes, substantially to the original specifications, to the British in advance of the 139 (British) LB-30's which had been originally ordered by the French. This compromise with most urgent requirements and available manpower maintained operations and made available full engineering strength for the AAF change program in January 1941.

This delay (which was agreed to by the AAF thru the medium of Contract Change) caused by the above is evidenced by the fact that delivery of the improved airplane, designated B-24D did not start until September 1941, or 10 months after delivery schedule called out in original production contract.

Further delays to the B-24 engineering program at San Diego occurred in January 1941, when Ford engineers began arriving in that city. Their task being to gather the necessary blueprints, templates, lofts, etc., to begin manufacture, to study Consolidated's method of handling engineering matters, to develop a workable engineering procedure for Willow Run, and to collect all other data which they considered necessary to go into production on the B-24. Although this time was well spent, as evidenced by the overall production record achieved by the participating companies, it hindered to large degree the efforts of the Contractor's engineering department because of the engineering manhours expended at a time when engineers were at a premium.

The Handling of Changes:

Throughout a period of approximately five years, during which time 6,725 airplanes of the B-24 type were produced in the San Diego Division, the number of master changes incorporated was 1,820 or 1 for every 3.6 airplanes delivered, many of which were considered unnecessary by the Contractor. This opinion is supported by the fact that 920 of the 1820 changes were incorporated in the B-24 after peak production had been reached and the airplane had been in combat some two years with great success as far as flight and combat characteristics were concerned.

Early in the program these changes were accomplished thru the Engineering Department but as the program developed, it became evident that a new procedure was necessary, and in 1942 the company was ready to use the MCR system when it was adopted by the AAF for use in all airframe plants. This system was first established under the direction of the Master Scheduling Supervisor. However, difficulties immediately arose thru the insistence of this supervisor that schedule on MCR changes must be met even though the engineering, tooling and planning departments had not performed to schedule. The confusion resulting in all departments from this practice is the main reason why the company failed to meet their schedule early in 1943.

In order to solve these problems, a master change board was created to coordinate all engineering changes with the engineering, planning and production departments before release into the system thereby giving all concerned a voice in the matter of scheduling. This practice worked fairly well, but the changes were coming so fast that this board could not keep up with them, and it was again

necessary to alter the system and establish an Engineering Control Board to screen all such changes at time of arrival with the purpose of deleting all changes not necessary. This Board functioned satisfactorily, and literally hundreds of "useless" changes were eliminated by coordination with the project office at Wright Field and the local AAF Plant Representative.

Perhaps of even greater importance in retarding progress than the number of changes themselves was the constantly changing priorities assigned to the changes. It seems obvious at this time that reassigning the priority of any change may readily mean that existing design work be thrown aside and a new design made to fit the condition of the airplane as of the new effective date. The chart shows that priority went repeatedly from top to bottom and back to top during a short period. It is true that the period may have been too long, but certainly the priority change lengthened rather than shortened the period.

During the war period at San Diego, four different models of this airplane were produced. The airplane was designated as B-24D through Serial No. 2533. With the installation of the nose turret under ACR 5310 on the 2534th airplane, the model designation was changed to B-24J. Beginning with the 3386th airplane, the tail turret was deleted for the purpose of modification center installation of hand held or Bell power boost tail guns and the model designation was changed to B-24L. Beginning with the 5743rd plane, the type A6C light weight tail turret was installed and the model designation was changed to B-24M. Subsequent changes were minor and did not therefore cause a change in model number.

The company did not use the block system until the B-24J airplane was produced. Prior to this time all changes were designated, for record purposes, in "Series" which is substantially the same inasmuch as the "series" were broken in increments of 5 to allow for minor changes by the using service. The great number of changes required the use of 38 different series designations and 59 block designations from inception of the B-24D (September 1941) to the termination of the program in 1945. This means that 97 different airplanes were delivered by the San Diego Division. Differences between major production blocks are shown on the following pages.

All plans on AC-4 7/22/42

Series X

Air Corps Serial Nos. 41-23640 (435) thru 41-23749 (544) -

M.C. No.	Title
47	Nose Gun Installation, revision of
194	Radio Controls for pilot - Location of
197	CFE C-6 Starter Series #43
206	G.F. Airspeed Indicator Installation in Bombardier's Compartment (Type C-14)
218	SCR-518 Radio Altimeter - (Partial - Group A Parts only) Furnishing equipment mounting brackets only Note: 218-1 - Install. - Furns. - SCR 518 indicator and control box (add brackets 41-23750(545)
236	Bendix Lower Turret - Elimination of - 41-11874 (370)
239	Gun Instln - Tunnel Door - .50 Cal.
239A	Tunnel Gun Stowage
251	Relocation of Vent for Auxiliary Power Unit - with extension cord added for use of A.P.U. outside for airplane
269	AFCE instln and M-1 Bombsight with provision for alternate installation of Mark IX Bombsight
307	Increase effectiveness of latches (Fore and aft movement of pilots seats)

AC-4 July 30, 1942 — Aug 19, 1941

Series V

Air Corps Serial Nos. 41-23750 (545) thru 41-23824 (619)

M.C.No.	Title
64	Tail Turret Gun Door latch
131	Filter - Vacuum Operated Instruments - Indicator started with 41-23755 (550)

Series V (Cont'd)

M. C. No.	TITLE
145	Oxygen Facilities Top Turret & Flight Deck (Temporary) Permanent started 41-23970 (765) Drain in Turret added 41-24100 (895)
195	Safety Guard for Bomb Rack Control Quadrant (starting with 41-23806 (601)
201	Master Power Switch - Study of (starting with 41-23794 (589)
218-1	Installation - Furnishings - SCR 518 Indicator & Control Box Addition of brackets
222	Oxygen Outlet for Side Gunners Note: Interphone Jack Box relocated beginning 41-24220 (1015)
242	Leading Edge Summer Fairing - Elimination of

Series VII

Air Corps Serial Nos. 41-23825 (620) thru 41-23859 (654)

M. C. No.	TITLE
129	Auxiliary Fuel Tank - Bomb Bay

9/11/42

Series X

Air Corps Serial Nos. 41-23860 (655) thru 41-23919 (714)

M. C. No.	TITLE
193	Bomb Rack Control System - Redesign & Study of (Partial)
219-5	Mount, Plates Co-linear Antenna 41-23864 (659)
263	"Y" Fuel Tank Venting System (starting with 41-23875 (670)
292	Doorway at Bulkhead Station No. 6 - Revision of (Starts on 41-23864 (659)
327 1/13 1/10	Reduce Cable Rigging Tension in Rudder Control Cable
327 2/13 1/12	Reduce Cable Rigging Tension in Aileron Control Cable
327 6/13 1/10	Reduce Cable Rigging Tension in Elev. Control Cable

Series XIII

9/24/42

Air Corps Serial Nos. 41-23920 (715) thru 41-23969 (764)

M. C. No.	TITLE
19	Oil Tanks - Self-Sealing
(a)	Component Parts for 41-23959 sent to Ft. North for Conversion to C-87.

Series XV

9/24/42

Air Corps Serial Nos. 41-23970 (765) thru 41-24099 (894)

M. C. No.	TITLE
55 (2 of 2)	Add. Sta. for Navigator
145	Adequate Oxygen Facilities for Top Turret & Flight Deck Partial - 41-23776 (571), Complete - 41-23970 (765) Note: Change position of fitting and added drain to top turret - 41-24100 (895)
279	Revision of Landing Gear - Reinforcement of Weak Spots
279 S3	Revision of Floor Structure Sta. #3 to #4.1 - 41-24055 (850) Note: Also on 41-24015 (810) thru 41-24017 (812)
279 S6	Reinforcement of Radio Operator's Floor - 41-24018 (813) thru MCR 279 S3
327 (6-13) (4-10)	Reduce Elev. Control Cable Travel from 18" to 9" -Started 41-24056 (851)
327 (6-13) (5-10)	Increase Servo Tab Motion on Elevators 765 to 1414 - 42-23970 to 42-40337

Series 20

11/20/42

Air Corps Serial Nos. 41-24100 (895 thru 41-24219 (1014)

M. C. No.	TITLE
40-2-4	Glide Bombing Attachment - Static Pressure Line to Bomber's Compartment
68-2	Hydraulic Gun Charger beginning 41-24203 (998)
166	Outboard Fuel Cells - complete installation started 41-24115 (910)
192	Propeller Modification 192-1 Wide Blade Propeller (starting 41-24179 (974) 192-3 New Double Capacity Governor (starting with 41-24179 (974)

Series 20 Cont'd

M. C. No.	TITLE
234	Astro Dome Defroster
237	Ring and Bead Sight Tail (Started with 41-24203 (998)
271-2	Add. Flex. Nose Gun Install. (986) 41-24191
271-7	Flexible Nose Gun Instln. (987) 41-24192
279-9	Nose Landing Gear Damper Accumulator Valve Cap Improvement
314	Bombsight Stowage - Relocation of Note: Effective only in Aps AAF #41-24100 thru 41-24269 (895 thru 1064) Deleted by MCR 406 AAF #42-27270 (1065) and subsequent
327 1-13 4-10	Reduction of Rudder Control Friction and Reduction of Rudder Cable Travel
344	B-24D Winterization Program (report) - started with 41-24135 (930)
351	AN-N-4 Gun Camera, Mounting Prov. - Starting with 41-24203

Series XXV

Air Corps Serial Nos. 41-24220 (1015) thru 41-24311 (1106)

M. C. No.	TITLE
138-5	Side Gun Installation
198	Engine Baffles - Revision of - Begin 41-24229 (1024)
238	Side Gun Ammunition Stowage
279-15	Replacement of MLG Shimmy Damper with reinforc. collar 41-24270 (1065) to 42-40587 (1644)
285	Heat for Flight Deck & Nose Compt. Additional: 285-1 Three Heaters added (Started 41-24133 (1028) 285-2 Addition of relay (1028) 41-24233 285-3 Larger Fuse Box (1015) 41-24220
358	Propane Gas Priming System - 41-24233 (1028)

Series 30

Air Corps Serial Nos. 42-40058 (1135) thru 42-40137 (1214)

M. C. No.	TITLE
271	Additional Flexible Nose Gun
271-3	Installation of New Lower Nose Gun
271-5-6	Addition of Right and Left Hand Nose Guns
271-10	Navigators Extension Light
271-11	Bomb Panel Splice
271-12	SCR 518 Equipment Routing of Cordage for
271-14	Installation of Flex Nose Guns
271-16	SCR 518 - Cordage - Rerouting of
274	Pilot's Side Window Blisters
286	Heating Cover for Bomb Sight - 421-40123 (1200) partial
300-1	Scanning Windows - Provision and Installation - 42-40108 (1185)
348	Retractable Skid Installation
445	Carburetor Air Scoop

Series 35

Air Corps Serial Nos. 42-40138 (1215) thru 42-40217 (1294)

M. C. No.	TITLE
28B	Marker Beacon Equipment (Change from RC-43 to RC-43B - 42-40211 (1288) Partial - Complete at 42-40266 (1343)
72-2	Tail Turret Blind Spot Reduction - 42-40158 (1235)
236A2	Removal of Armor Plate (Bendix Lower Turret Prov.) 42-40148 (1225)
423-1	Redesign of Engine Cowling Support Brackets (42-40140 (1217)
463-1	Reinforcement of Rudder Ribs (42-40213 (1210) Partial at 42-40165 (1242)
472	Rev. of Fuselage to accommodate Martin Turret - 42-40188 (1266) Note: Also in 42-40167 (1244)

Series 40

Air Corps Serial Nos. 42-40218 (1295) thru 42-40257 (1334)

M. C. No.	TITLE
132-2 (Sup. 4)	New Demand Oxygen System - A12 Regulators - Pressure Gage - 12 Stations
193-7	Bomb Rack Control System - Redesign and Study of
253-1	Sound-proofing - See 253-D1, Part 4
295-1	Revision of Tail Formation Light Circuit
327	Lightening of Control Forces (Complete Installation)
354-1	Supercharger Deflector Plates
421	Emergency Nose Wheel Lock

Series 45

Air Corps Serial Nos. 42-40258 (1335) thru 42-40322 (1369)

M. C. No.	TITLE
288-1	Marker Beacon Equipment - Changed from RC-43 to RC-43-B 42-40266 (1343)
288-1	Oil Immersion Heater - 42-40292 (1369) and on - Deleted except for Oil Tank Flange and Pipe Plug 42-40859 (1936)
327 2-13 4-12	Reduce Cable Travel by replacement of a 20-tooth sprocket with a 16-tooth sprocket on the Aileron Gear Unit - 42-40263 (1345); also in 42-40258 (1335), 42-40259 (1336), 42-40262 (1339), 42-40263 (1340)
348-5	Improvement of Tail Bumper Skid Shoe was incorporated 42-40273 (1350)
505	G.T.E. A-2 Bomb Rack Release Units - Correction of - 42-40260 (1337) Note: Also 42-40261 (1338) thru 42-40264 (1341)

Series 53

Air Corps Serial Nos. 42-40345 (1422) thru 42-40392 (1469)

M. C. No.	TITLE
50	Incorp. of Automatic Oil Cooler Shutters (9") - Started 42-40354 (1431)

Series 53 Cont'd

M. C. No.	TITLE
55A1	Lower Turret Heater Receptacle - 42-40376 (1453)
171	Carburetor Air Filter
279-12	Uplock Spring Main Landing Gear (42-40385 - 1462)
370-1	Tail Turret, Foot Firing Provisions - 42-40364 (1441)
393	Stabilizer Reinforcement

Series 55

Air Corps Serial Nos. 42-40393 (1470) thru 42-40432 (1509)

M. C. No.	TITLE
68-1	Tail Turret Door Latch Redesign
192A	Propeller Blade Modification - 42-40408 (1485)
279-16	Tail Bumper Gear Uplock clip
470-3	Relocation of Engine Oil Breather (Started 42-40427 (1504)
494-1	Removal of A-12 Fire Extinguisher System

Series 125

Air Corps Serial No. 42-41003 (2080) thru 42-41047 (2124)

M. C. No.	TITLE
146-7	Nose, Passageway, redesign Bulkhead 2.0
191-A1	Installation Armament Bomb Racks, Type A-2 Release Units
413-2	Bulkhead Revision - Wing Outer Panel - 42-41033 (2110) Note: Superseded 413-1 at (2110) 42-41033
537D	Armor Plate for Bomber - Sta. 2.0 -Deletion of

Series 135

Air Corps Serial No. 42-41093 (2170) thru 42-41137 (2214)

M. C. No.	TITLE
70-2	Tail Turret - Relocation of Additional Bulbs for N-6 Sight

Series 135 Cont'd

M. C. No.	TITLE
337C1	Carburetor Mounted Primer - Bendix PL-392434 in lieu Bendix 392192 - 42-41115 (2192)
376-1	Antenna Reel R/L -42 and Fairlead F-10 and details
417-4	44" Van Ornam Retractable Ball Turret - (Turret well replaced to suit new turret; also floor from Sta. 6 to 7. Beltframe 6.1 and bulkhead 7.0 redesigned to suit) Partial 42-41113 (2190)
547-1	R-1830-65 Engine in lieu of R-1830-43 - 42-41115 (2192)
561-1	Lower Turret Support Beam - Addition of Access Hole - 42-41113 (2192)

Series 145

Air Corps Serial No. 42-41173 (2250) to 42-41217 (2294)

M. C. No.	TITLE
105A1	Redesign and relocation of draft signal stowage rack
468E	Bomb Bay Auxiliary Fuel Cell System
536-1	Wheel Control Switch - SCS PB Switch - 42-41187 (2264)
537-B2	Armor Plate and Brackets for Side Guns - Deletion of 42-41196 (2275)

Series 150

Air Corps Serial No. 42-41218 (2295) to 42-41247 (2334)

M. C. No.	TITLE
288C1	Oil Immersion Heater (2331 and on)
349A1	Flare Chute Door Inner and Outer - 42-41248 (2325)

Series 155

Air Corps Serial No. 42-72765 (2335) to 42-72814 (2384)

M. C. No.	TITLE
132A1	Redesign of O2 Panel

Series 155 Cont'd

M. C. No.	TITLE
193B	Bomb Rack Control System - Cam Type - Additional modification Alternate and Interchangeable to 42-73065 (2635)
224-1	Grooving of Bomb Door Cable Drums
299B	Pilot's shoulder safety harness - 42-72799 (2369)
355C	Supercharger Regulator Oil System - 42-72769 (2339)

Series 165

Air Corps Serial No. 42-72865 (2435) to 42-72914 (2484)

M. C. No.	TITLE
274A-1	Side Window Blisters - Radio Operator (Sta. 3.1 - 3.2)
451-1	Formation Lights - Simple Installation
531-C2	Bomb Quadrant
531-C45	Nose Turret - CVAC 32F5800-3 (m-3) Production Install.

Series B-24J-1-CO

Air Corps Serial Nos. 42-72964 (2534) thru 42-73014 (2584)

M. C. No.	TITLE
531C1	Nose Turret - CVAC 32F5800-3 Production Instln - Armament
531C-50	Pitot Static Mast Instln - Revision of
537E-1	Armor Plate - Tail Turret - (Lower at knee) - deletion of 42-72985 (2555)
578	Designation B-24J in lieu of B-24D

Series B-24J-5-CO

Air Corps Serial Nos. 42-73015 (2585) thru 42-73064 (2634)

M. C. No.	TITLE
68B1	Tail Turret - Instln of Spring to improve Operation of Door Latch on Model 3 Turret
95A1	Navigator's Observation Dome

Series B-24J-5-CO Cont'd

M. C. No.	TITLE
550-1	Bomb Hoist Pulley Bracket (100 to 1100# bombs) Strengthening of - 42-73030 (2600)

Series B024J-30-CO

Air Corps Serial Nos. 42-73265 (2835) to 42-73314 (2884)

M. C. No.	TITLE
359-2	Electronic Turbo Regulator - Installation of
417-11	Bulkhead 7.0 - Addition of Lightening Cover Holes

Series B-24J-55-CO

Air Corps Serial Nos. 42-99936 (3085) to 42-99985 (3134)

M. C. No.	TITLE
426-8	Power Plant Interchangeability - Exhaust Collector Shroud and Cowl Flap - 42-99981 (3130)
515-14	Relocated of Command Receivers to Clear Cabin Heating Ducts
575-1	Gun Heaters - Electrical Type J-1 - Provisions for

Series B-24J-75-CO

Air Corps Serial Nos. 42-100136 (3285) to 42-100185 (3334)

M. C. No.	TITLE
531R1	Nose Turret - Motor Products MPC 5800-5 Prod. 32-100156 (3325)

Series B-24J-80-CO

Air Corps Serial Nos. 42-100186 (3335) to 42-100235 (3384)

M. C. No.	TITLE
466-2	Install Motor Products Tail Turret 32F5800-5 - 42-100201 (3350)
466-11	Motor Products Tail Turret - Installation of Re-design of Floor between Sta. 8.0 and 9.2 and rework of Floor Between Sta. 7.3 to 7.4
592-1	Main Fuel Cell Backing Plates - Rear Spar

Series B-24J-115-CO

Air Corps Serial Nos. 42-109889 (3685) to 42-109938 (3734)

M. C. No.	TITLE
417M	Modified Briggs Bottom Turrets
472A1	Top Turret - Improvement of Seal - 42-109905 (3702)

Series B-24J-130-CO

Air Corps Serial Nos. 42-110039 (3835) to 42-110088 (3884)

M. C. No.	TITLE
202A3	Life Raft - Ejection Means, Modification of - 42-110070 (3866), 42-110072 (3868), 42-110075 (3871) and on
454-1	Safety Device to Prevent Surface Controls from Locking when Airplane is in Flight - Note: Eng 320696 "J" accomplished on 42-109940 (3736) thru 42-109949 (3745), 42-109953 (3749), 42-109956 (3752), 42-109962 (3758) thru 42-109964 (3760)

Series B-24J-18500

Air Corps Serial Nos. 44-40849 (4785) thru 44-40948 (4884)

94D	Navigator's Astro-Compass Mount Instln - Redesign of
146-2, 3	Passageway to Nose Compartment - Improved Study means to
531M1, 10, 11,13,14	Nose Turret - Prod. Instln - Change to N. American Version

Series B-24J-195-CO

Air Corps Serial Nos. 44-41049 (4985) to 44-41148 (5084)

M. C. No.	TITLE
95B	Redesign of Navigator's Dome Escape Hatch Latch 44-41135 (5071)
504M	Modification Main Landing Gear Pivot Housing Assy. T.O. 01-5-111 44-41114 (5050)
515F1	Cabin Heat Instln - Mod. of -44-41089 (5025)

Series B-24L-1-CO

Air Corps Serial Nos. 44-41390 (5326) to 44-41488 (5384)

M. C. No.	TITLE
466F	MPC Tail Turret - Rev. to Fuselage Fairing for - 44-40426 (5362)
575D	Gun Heaters in Emerson Nose Turret - Addn. of Cord Support Clip - 44-41399 (5335)

Series B-24L-5-CO

Air Corps Serial Nos. 44-41449 (5385) to 44-45148 (5484)

M. C. No.	TITLE
274F	Pilot's Side Window, Instln of Blister Escape Type - Flat Panel to be installed in lieu of truncated cylinder - partial
346-2	Instln of RC-103 Radio Equipment AN-100 Antenna and Receiver BC-733-A
407-1	Elimination of Gear Boxes in the Aileron Control
578A	"Model Designation" - Letter change concurrent with Hand Held Guns in lieu of Tail Turrets",
606B	Scanning Window for Navigator: Five inch Blister in lieu of nine inch 44-41465 (5401)
611	Side Window for Bombardier - Addn of Flat Panel for Side Vision

Series B-24M-1-CO

Air Corps Serial Nos. 44-41807 (5743) thru 44-41848 (5784)

M. C. No.	TITLE
466H	Tail Turret - Instln of Type A-6C - 5743 - 44-41907

Series B-24M-5-CO

Air Corps Serial Nos. 44-41849 (5785) thru 44-41948 (5884)

M. C. No.	TITLE
128F12	Heat Anti-icing - Improvements Found Necessary by Flight Testing
470A	Engine Cowling Support - Strengthening of Attachment

Series B-24M-5-CO Cont'd

M. C. No.	Title
472B1	Top Turret - Revision of Mounting for - 44-41898 (5834)
648B	Rudder Tab Control Fairing - Reinf. of

Series B-24M-15-CO

Air Corps Serial Nos. 44-42049 (5985) thru 44-42148 (6084)

M.C. No.	Title
138W	Side Waist Guns - Inspection and Rework of N-6 Swivel Mount in accord. with T.O. 11-10-31 of 9-29-44 - (6019) 44-42083
154-12	4000# Bomb Installation - Standard M-56 - 44-42099 (6035)
408A2	Cowl Flaps - Fixation of Upper Outer Flaps - 44-42120 (6056)
457B	Aileron Tab - Increased Span - 44-42114 (6050)
603A1	C-1 Auto-pilot & M-7 Bombsight - Inst. of In Standardized Aps - Partial - 44-42049 (5985) - complete 44-42099 (6035)

Type of Changes:

In future consideration of the subject of engineering changes, cause and effect, and the development of a new and better system for handling those which are essential, it must be recognized that two basically different types of changes in drawings and shop practice were included under this general heading. First, there were a very large number of corrections in design, drafting and/or dimension which had to be made and which were improperly called changes. Second, there were a large number of structural and equipment changes recommended by the Contractor for engineering or production reasons, or ordered by Army for tactical or other reasons. Both interfered with production acceleration, and neither should be permitted during the next war time acceleration period. The first class should be entirely eliminated during the peacetime small volume production period by the program discussed throughout this report. The second class of changes can not be imposed on production lines by the Army while it secures at the same time the maximum amount of equipment for the combat air forces in a minimum of time.

Approval Authority:

A major factor in the time cost of making these changes was the requirement for detailed approval in Wright Field. There seems to be no more reason for a detailed Army approval of the new parts than for those being replaced. It is recommended that this authority be delegated to the Government representative at the plant, to materially reduce the time cost of making essential changes.

Advent of the B-24 Committee:

As noted elsewhere in this report, the B-24 Committee, at the insistence of the AAF, was established in March 1942 to coordinate the many production and engineering problems that appeared in the four plants producing this airplane; namely, Ford, Douglas, NAA, and Consolidated. Although the Committee was patterned in general after the B-D-V Committee, its functions were all inclusive and unfortunately did not include subcommittees. As this Committee began operations, however, engineering changes were becoming more and more a serious bottleneck and were complicated by the fact that all engineering changes were to emanate from San Diego. It was found that in many cases data sent to the participating companies arrived too late for incorporation in the desired block, or the design was such as to make it impracticable (without redesign) for production in that particular plant. This was particularly true in the case of Ford, and is believed due primarily to the fact that Ford as an automobile manufacturer failed to appreciate the procedures and methods being used by the Aircraft industry. As a result of these complications, and, in an endeavor to improve the picture, an engineering sub-committee was established during May 1942.

This sub-committee was very active in the engineering picture and did much to bring Consolidated and Willow Run closer together by the coordination and simplification of both companies' engineering systems.

Recommendations:

It is evident that numerous changes must be made in the existing engineering procedure if maximum results are to be obtained in a future emergency. Such changes should include the following:

1. Contractor should be allowed and encouraged to design and fly the prototype airplane to determine its characteristics before giving too much attention to the details of the equipment that is to be installed in the completed product.

B-24D

ENGINEERING PRIORITY RECORD

(BETWEEN MAY 23, 1942 & APRIL 22, 1943)

OF

MCR- 171 CARBURETOR AIR FILTER
MCR- 146 NOSE PASSAGEWAY
MCR- 240 REMOVING RADIO OBSTRUCTIONS
MCR- 230 BENDIX NOSE TURRET
MCR- 138A SIDE WAIST GUN
MCR- 405 IMPROVE FUEL CELL REPLACEMENT
MCR- 417 BALL TURRET
MCR- 423A CENTRALIZED FUEL SYSTEM (AUX.)
MCR- 54, 81 EMERSON NOSE TURRET
MCR- 413 CENTRALIZED FUEL SYSTEM (MAIN)

PREPARED BY:

E. H. COOK.
4-16-43
B-24 PURE GROUP

2. Establish a standard drawing room procedure for use by all companies on all military airplanes to insure that all drawings, prints and specifications will be alike reproducible and understandable by all participating companies.

3. On all new models of aircraft, the AAF should specify the peak production requirements desired in first design contract.

4. At the start of a future program, the design should be frozen until the peak production has been reached, and then only those changes vitally necessary to safety and combat effectiveness should be made.

5. All specifications such as AN, AC, Navy, CAA and Federal must be coordinated with and preferably issued from one central agency as a single standard specification, taking into consideration all the specifications then existent in industry.

6. The location on site of final authority on design changes.

PRODUCTION METHODS AND TOOLING

Consolidated's production effort for the war emergency resulted in the sudden growth of a small job shop making airplanes by hand to a very large integrated factory using to some extent modern industrial methods. This gradual growth was very well suited to the production of the B-24 in that it had a flexibility necessary for the incorporation of the many design changes. This production system was weak in that little detailed planning could be done in advance under the rapid schedule changes and it required a very large amount of manpower.

The Plan:

Consolidated did not have a complete overall plan for the production of the B-24. The facility had been sponsored and set up as a Navy source for heavy flying boats. During a lull in Navy flying boat programs the Army placed a contract for the XB-24 and other contracts followed. When the first production contract was signed, $3,000,000 was spent in expanding production facilities. The next production contract necessitated the expenditure of approximately $22,000,000 to build and equip Plant #2. With each change in airplane delivery schedule the contractor made a production plan to fit that schedule plus a little more.

The contractor expected to make and assemble all the required parts in his own plant except standard parts, such as nuts, bolts, fittings, terminals, etc. and parts requiring special skills and equipment such as landing struts, pumps, electric motors, etc.

The existing production and supporting departments were to be expanded as rapidly as possible.

Plant #2 was designed to fabricate and assemble subassemblies to feed the production line at Plant #1.

The tooling plan consisted of duplicating the existing tooling to obtain more production.

Workability of the Plans:

To explode a plant making a small number of airplanes by hand into high gear production many requirements must be met.

1. Engineering must be completed far enough in advance to allow for production planning. The lofting and templates must be complete and accurate.

2. Production engineering must be complete so that production breakdown of the product is available for shop planning.

3. Engineering changes must be held to a minimum and the necessary changes must be completely planned in advance.

4. The tool planning and design departments must be adequately staffed and organized.

5. Tooling, dies, jigs and fixtures and master controls must be accurate and available for rapid acceleration.

6. Large tool making resources with many skilled workers must be available at the start of each program and also available to handle necessary changes.

7. Raw materials and purchased parts must be available and their control in the plant must be accurately timed.

Strength of the Plans:

Consolidated always planned for a slightly greater production than was currently in work. Under this planning manufacturing space and machine tools were always available.

Throughout the war emergency the Contractor had in production, in addition to the B-24, several models of flying boats for the Navy. This multimodel production necessitated a rather large tooling department and tooling for changes could be fabricated rapidly.

The effective use of Plant #2 for fabrication and sub-assembly was possible as the airplane was broken down into smaller sections so allowing the use of more workers per hour with greater efficiency.

The Contractor's tooling was not elaborate nor rigid as compared to Ford's and as new techniques were worked out they could be used readily. Since the tooling plan was more flexible, actual production could be attained sooner.

Weakness in the Plans:

Due to the chronic shortage of skilled personnel in the Engineering Department, engineering information on the B-24 was never quite accurate, up to date, nor complete. This lack of information delayed every other function in the production cycle and necessitated much shop engineering.

The AAF requested and Consolidated's engineers attempted to incorporate too many changes without proper planning which resulted in confusion and delay on the production line.

The Contractor's expansion from low production using skilled hand workers and the lack of high production "know-how" necessitated the use of excess labor as judged by automotive production standards. Since skilled workers were not available, first local people and later large numbers of in-migrant workers had to be hired and trained which delayed the progress. As the program developed the shortage of manpower would have limited the actual production at San Diego, so feeder shops and outside subcontracting had to be established to take the work to the worker. The breakdown of the airplane into smaller sections was not done until the shortage of skilled workers made it imperative.

The lack of rigidity of the fixtures themselves proved a very serious handicap, and it finally became necessary to use a dozen men full time in a futile effort to check and to restore alignment. When the fixtures were redesigned and rebuilt using sixteen inch steel tubing in the place of four inch, the problem was solved and mating difficulties were eliminated.

Working out the Plans:

The tooling used in the production of the experimental models and the LB-30 were on hand and were used to start the production of B-24's. Production "know-how" of the original staff was available for starting the production line.

The Engineering Department was on hand to iron out inaccuracies and establish masters.

The Tooling Department was well equipped and a relatively large staff was on hand which did allow rapid tooling. However, due to the large number of changes released, at times it was necessary to send some tool work to outside contractors.

The original production tooling plan for 90 B-24's per month had been substantially released to the tool fabrication departments in the early fall of 1941 and was substantially completed by end of that year.

Consolidated, being the design prime contractor, was required to produce or make available to the other contractors tool designs and many master gages in addition to tooling for many of the sub-contractors and all feeder plants. To accomplish this project the Contractor developed the tooling dock, which saved a great amount of layout and construction time. (See following illustration of a new "three dimension" surface plate.)

Assembly Tooling:

The assembly tooling at the start of the program was used to build complete major assemblies in the jigs. The workmen were skilled in building and installing operations. As the production was stepped up and additional skilled all-around mechanics were not available, these major assemblies were repeatedly broken down into smaller and smaller sections. This breakdown allowed more people to work on each section and also required only the development of special skill by the worker for one simple operation. As production experience increased a further division of work was made. The time in the main assembly jigs was further reduced by using the main jigs to align the parts and install only the aligning rivets. Detail riveting and accessory parts were installed in adjacent moving assembly lines. By the time this plan was operative the subassemblies fabricated at Plant #2 were complete and required only mating and assembly at the main assembly line Plant #1.

An example of the flow for the wing department follows:

1. Cutting and forming of parts for wing.

2. Assembly and key riveting of wing members in the wing jigs.

3. Transfer of partially complete wing to moving wing line where detail riveting, installation of components, plumbing and wiring is made.

4. Delivery of complete wing to final assembly line Plant #1 where installation to the fuselage is made.

The 12 wing jigs were of heavy steel tubing construction served by overhead cranes, and having two working levels for convenience.

The moving conveyor line for detail work held the wing in the flat position and was approximately 700' long.

The airplane fuselage cabin was built in a similar jig. After structural assembly it was taken apart at the vertical center line for installation of components, plumbing and wiring and then mated on the final assembly line. The other subassemblies were constructed on similar jigs.

Extent of Tooling:

The number of tools, jigs and fixtures actually used to produce the B-24 was about 45,000 and with the replacement of tools required by design changes the total quantity produced was far greater. The Contractor was too busy and lacked the skilled manpower to develop very many new processes of manufacture and on the whole stayed within the general practices of the aircraft industry. Some production short cuts were developed and among those worthy of mention are the sheet deburring machine and the tooling dock.

The sheet deburring machine passed the drilled sheet thru rubber covered rollers and scraped the burrs against fixed steel knife. The operation was very fast and effective.

The tooling dock is a rigid but movable system of accurate straight edges in three dimensions which saved many manhours in the layout and duplication of jigs and fixtures as well as master gages and templates. The fixed longitudinal straight edges are supported by a massive reinforced concrete superstructure and base insulated from the building. The vertical and transverse straight edges are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Interior photo taken from overhead crane of upper level B-24 Nose Buck line showing old stationary buck type tooling. November 1942.

Photo of improved method showing components broken down in small panel assemblies.

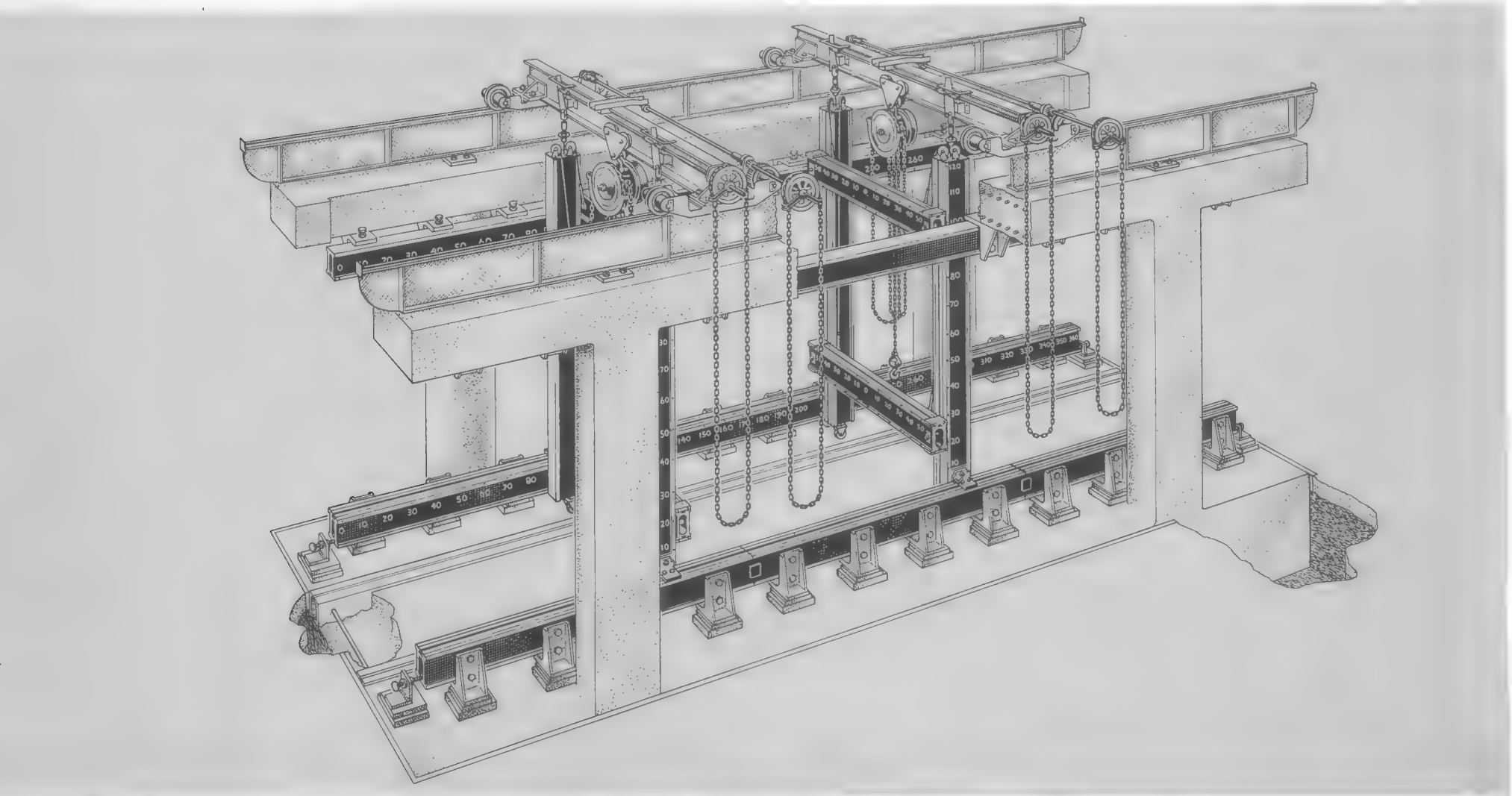
Photo taken 14 April, 1944.

B-24 furnishing lines. Showing stock areas, then side panel lines.
Photo taken 14 April 1944.

Erco Riveting. Improved method indicating operator completing segment small panel assembly.

Photo taken 14 April 1944.

FOUR fixed longitudinal straightedges are mounted on the supporting structure — two on the foundation, two on the superstructure. . . . Vertical straightedges are mounted on the longitudinal straightedges. One or more transverse straightedges can be mounted on one pair of vertical straightedges to comprise a set. If the plane of a pair of vertical straightedges is visualized as a drafting board, the transverse straightedges can be considered as analogous to the conventional parallels used on such a board. . . . . Transverse straightedges are balanced for easy operation by counterweights inside the vertical straightedges. A set of vertical and transverse straightedges can be moved easily to any position along the longitudinal straightedges by means of an overhead crane. A screw jack at the foot of each vertical straightedge permits adjustment to relieve any strain on the longitudinal straightedge.



same tooling methods could not provide the precise co-ordination control which such a manufacturing program requires, aircraft manufacturers have had no alternative. . . . Common practice has been to fabricate costly, complex dummy master gauges from which to produce a limited number of relatively large assembly fixtures — large fixtures in which major parts of the airplane could be assembled as units.

In using such methods, efficiency was further sacrificed to expediency. Only a limited number of production mechanics could work in each assembly fixture, and every mechanic had to be craftsman and contortionist combined — hand fitting, cutting, drilling, and riveting while squeezing into tight spots in the large assembly fixtures. It was difficult to train and use semiskilled or physically handicapped workers under such conditions. . . . Such production methods violate the first principle of efficient manufacture; viz., *effective employment of labor requires that the skill involved in each operation be reduced to a minimum.*

Then —

Out of this welter of confusion was born the MASTER Tooling Dock, conceived to reconcile a complex system of interrelated manufacturing problems — problems whose core lies in assembly tooling.

These were the problems:

Is it possible to establish rigid dimensional control over assembly tooling directly from engineering design?

Is it possible to so apply this rigid dimensional control as to produce rapidly and at low cost . . . assembly tools that will *automatically* provide the positive, progressive co-ordination essential to line production?

The MASTER Tooling Dock was designed to answer these questions positively and affirmatively. The consequences of the technique are so extensive as to effect a pyramiding increase in efficiency. Engineering design, tool design, toolmaking, and product fabrication can now be simplified and correlated about a single nucleus — the MASTER Tooling Dock.

movable. The straight edges are of box construction with a tee slot extending the full length. The working surfaces are carefully machined and scraped to close tolerances. A single line of bushed .500" diameter holes extends the full working surface length of each straight edge on exactly 10.000" centers. An overhead crane is used to move the various elements. Contractor estimates that a 60' x 10' x 10' tooling dock can be built for $50,000.

Early in the program use was made of prepunched pilot rivet holes. These pilot rivet holes were drilled to rivet size at assembly in the jigs. Later as personnel became more experienced and the jigs in use were more accurate, full size rivet holes were prepunched in the skin but this type of prepunching was not very successful.

Throughout the production period steel faced blanking dies were used with rubber strippers. Forming of parts were done with stretch presses and drop hammers using zinc and kirksite dies. Experimental and small run parts were made by hand forming or by wood form blocks in drop hammers.

Difficulties:

1. Many engineering changes which required immediate incorporation on the airplane made obsolete both tools and parts in manufacture.

2. Due to manufacturing and transportation time, many tools that were subcontracted were obsolete upon receipt, due to engineering changes and required considerable reqork, if not scrapping.

3. Difficulty with subassembly and feeder plant production was caused by engineering changes. Changes in tooling and material, again due to transportation and manufacturing time, could not catch up to the change schedule and in many cases necessitated the set up of jigs at San Diego to correct assemblies received.

4. The shortage of manpower at San Diego necessitated an increase in the amount of work sent to feeder and outside subcontracting plants which in turn required more tooling to send with the job.

5. The necessary use of unskilled assembly workers at San Diego required the reqorking of many existing tools to improve accuracy of finished parts so they would "fall into place."

6. The ultimate use of a high percentage of female labor required super special attention in tool design and considerable rebuilding.

Changes Made:

The most important change in manufacturing methods was the moving back of final assembly operations into the subassembly departments so that when subassemblies reached the main assembly line mating and rigging were the only operations required. This change required more complete and accurate tooling in subassembly departments. As manpower shortages in the San Diego plant became more critical, more work was sent to feeder plants and subcontractors. Much of this outside work such as wiring harness and formed tubing required fixtures that had not been needed in original final assembly operations.

The initial setup for formed parts had been drop hammer dies of Kirksite with the use of rubber for back up. As production experience increased and the design became more stable zinc and Kirksite dies were used which required much less hand work to finish parts.

Magnitude of Tooling:

The Consolidated Aircraft San Diego Plants represent an investment of approximately $60,000,000 of which about one-half is machine tools and fixtures. This represents a large investment in terms of product produced as compared to high production industries. However, the airplane is not a high production industry and very little automatic or semi-automatic machinery was used and machine and manhour costs per operation were high.

A large part of the tooling expenditures were made to incorporate the large number of engineering design changes. The breakdown of "going costs" of the tooling department is as follows: Maintenance 20%, Army sponsored design changes 45%, Consolidated sponsored design changes 14%, and improvements in production methods 21%. This expenditure of only twenty cents for maintenance out of every dollar of "going costs" of tooling points clearly to the urgent need for the constant and further industrialization of the airplane business and the ability to recognize and satisfy this need.

Recommendations:

Because neither time nor skill can be made available on and after M-Day, the tooling recommendations for war time production acceleration in the ideal or shortest time are as follows:

1. Peace time preparation for war production should include complete tool design of accepted airplanes. One set of this tooling per model should be built and production proven by producing the peace time requirements for airplanes from it. As changes to the airplane or the methods are made the tooling should be brought up to date.

2. As airplanes are released by A&F for engineering development the contractor should be advised of the war time production rate per month so that the airplane may be designed for the required volume, and the type and quantity of tooling can be determined. The war time production rate should also be known to and for the associated prime contractors, if any, so that the overall tooling program can be determined.

3. At the time the airplane design is approved the master control gages should be made and their accuracy verified. As changes are made in the airplane the master control gages should be brought up to date.

4. The Production Department should have a voice in the design of the airplane. Many times a slight change in the layout of the airplane will save many manhours in the Production Departments. Production know-how can greatly improve the interchangeability and servicing of the airplane.

5. Production planning should be complete. The manufacturing breakdown for high production should be planned and one set of tooling provided for this breakdown. Supporting departments such as Material Control, Production Control, etc., should have complete high production planning paper proven by actual use.

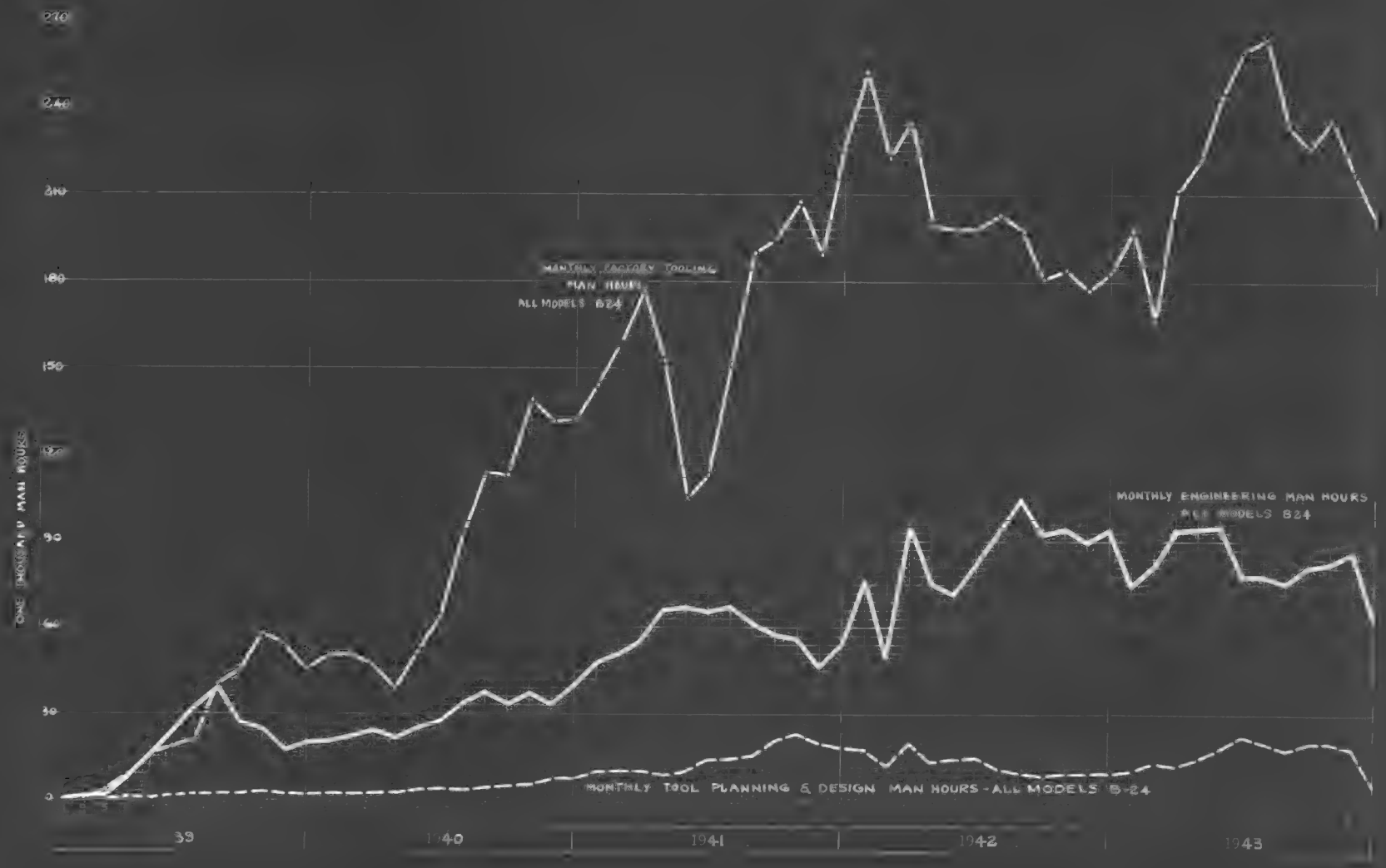
6. Production efficiency is much higher in a plant making only one model airplane for one using service. Segregation of material requires more space and manpower for multimodel manufacturing. Further difficulties are encountered in scheduling manpower and machine time and determining which model has highest priority on existing production capacity. War time production for any one model will use the total plant capacity, and further expansion of the plant will overtax the local labor supply.

7. A small peace time contract should be given to associated prime contractors so that they may study the product, make complete production plans and arrange for duplication of tooling required. The associated prime contractors should study the production and tooling in the design prime contractor's plant.

8. There should be two sets of master control gages, one set dispersed to another location to protect the production program of both design prime and associated prime contractor in advent of accident or enemy invasion.

CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

MONTHLY TOOLING, ENGINEERING AND TOOL PLANNING AND DESIGN MAN HOURS
ALL B24 MODELS



Tooling and Engineering Man-Hours Build-up by Months - B-24 All Models

		Tool Planning & Design		Factory Tooling	Engineering	
Jan.				262,850		
Feb.				222,974		
Mar.				235,288		
Apr.				198,978		
May				197,482		
June				197,080		
July				203,319		
Aug.				197,064	105,563	
				180,768	82,440	
				184,525	94,936	
				177,385	89,339	
				183,640		
				197,080		
				167,462		
				211,842		
				222,979		
May				244,369		
June				260,880		
July				264,013		
Aug.				233,180		
				226,620		
				235,353		
				217,746		
	132,448			198,224		
	144,480			148,236		
	158,095			180,020		
	177,804			183,455		
	163,759					
	105,615					
	113,602					
	151,361					
	190,618					

9. To start high production of airplanes in time of national emergency, machine tools to produce the production tooling would be the first shortage, which would retard rapid production acceleration. Hence the supply of machine tools should be direct Government issue to insure best possible utilization.

It is estimated that in following these recommendations to prepare for high production of an airplane the size of the B-24, an expenditure of $5,000,000 for high production tooling would shorten by six months the time required to reach a sustained peak production. Establishment of these ideal conditions will, it is conservatively estimated, shorten to months the period of years which was required to get the B-24 up to peak during the last war. The ideal time set is twelve to eighteen months.

MACHINE TOOLS

Summary:

Consolidated's procurement of machine tools for the B-24 program took place at several different periods, with some minor tool buying to fill production gaps and improve methods between the major periods of buying. To a large extent, the machine tools purchased can be said to apply to the San Diego plant expansion to accommodate production plans for PBY5 and PB2Y3 models as well as the B-24. No actual production delays were caused by the lack of machine tools. However, some extra manpower was required at times to fabricate parts by hand which could have been better done if machine tool delivery had been closer to schedule.

The Plan:

Consolidated planned the procurement of machine tools to meet the requirements of the major schedule changes with fill-in purchases to round out production or improve methods. From August 1940 to April 1942 there were three major tool procurement programs, two were for production expansion and one was to round out the facility. After April 1942 purchases were mainly for replacement or improved methods and the volume was small.

Procurement:

Ordering under the first plan took place between August and November 1940. About 200 items of machine tools were purchased to outfit the expansion of Plant #1. This was the first machinery

ordered for the B-24 program. Almost all of this equipment was delivered from dealer stocks or from factory floors within 30 to 60 days. A major exception in the delivery experience was a large hydraulic press built up by "Birdsboro" and delivered by diversion to San Diego somewhat past due but still within 90 days from placement of the order.

About the middle of the first ordering period in the fall of 1940, the machine tools for Plant #2 were ordered. These tools were required for the two-plant production of the B-24. This procurement started in October 1940 and item delivery was largely completed in the early fall of 1941. This program was the largest of the three major programs and included from ten to thirty each of most of the production equipment items ordered. Deliveries of tools ordered in this group stretched out considerably longer than on the first program particularly on orders placed in the middle of 1941. Plant #2 being under construction during this period, machine tool orders were placed far enough in advance that delivery was made when equipment was needed. By December 1941 the equipment and tools procurement program for the airplane schedules then in sight was complete.

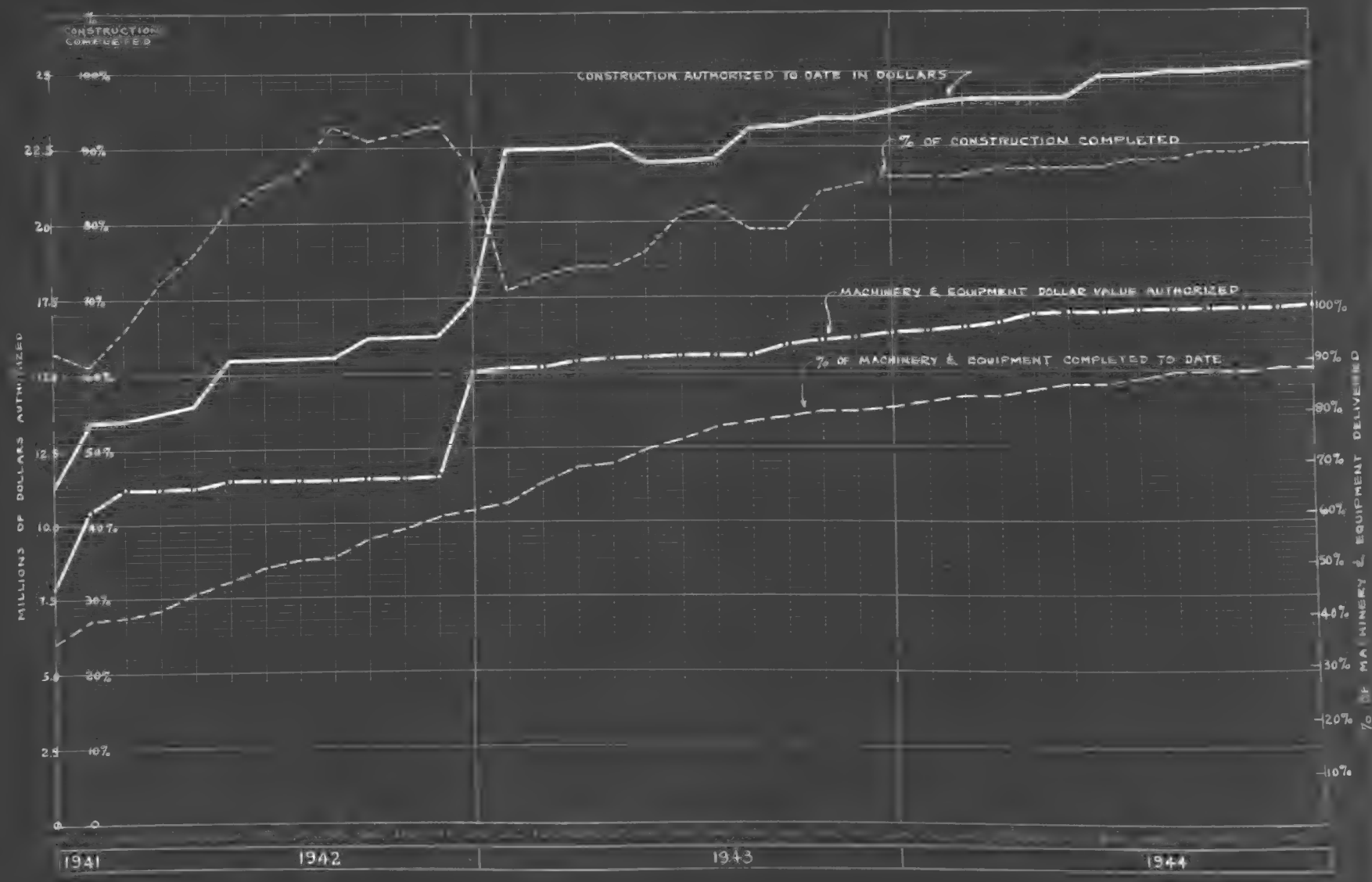
In March and April of 1942 the filling in and rounding out orders were placed for about 300 items requiring delivery by 1 July 1942. Actual deliveries were made within requirements on much of the smaller equipment but there were delays of four to five months on the larger items. It was during this period that the machine tool picture was most confused and urgency standings were being adjusted to the varying war production programs. Schedule rearrangements of machine tools by Aircraft Scheduling Unit worked to the advantage of the B-24 program on many of these items.

After the March and April 1942 program, ordering of machine tools was not large and was restricted to improved methods or to make production capacity adjustments.

The worst delays in machine tool ordering occurred after the Spring of 1943, when central Wright Field control of WPB priorities was dropped and the determination of machine tool needs was decentralized to be coordinated between AAF Procurement District Offices and local WPB boards. Local AAF Plant Representative and Procurement District officers questioned the need for additional equipment without a proper appreciation of the required increase in labor efficiency possible. Under this system of priority approval, some cases required as high as a month to process the priority papers and place the purchase order.

CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

MACHINERY AND EQUIPMENT
PERCENTAGE COMPARISON



RAW MATERIALS AND PURCHASED PARTS

Summary:

The Bill of Material was never up to date and as a result it was found that the practical way to purchase materials was on the basis of shop usage. This system of purchasing worked very well and the application of the incentive pay plan to the buyer, material control and stock room keeper was effective in controling inventory. The follow-up men located in principle cities in the East aided greatly in expediting from vendors behind schedule and in obtaining materials on short notice for urgent engineering changes.

The Plan:

At the start of the war emergency Consolidated's plan was to expand the existing purchasing department as required. It required a change in policy shortly, for war time purchasing necessitated locating a vendor with the material on hand or one able to produce quickly rather than the one with the best price.

The initial orders for material were placed on Bill of Material requirements and there was some interchange of material between contracts. Lead time, in general, for raw material was six months and purchased parts was two to five months, depending upon the nature of the item. Purchases were for the entire contractural requirement.

Consolidated was a fabrication and assembly plant and all forgings, castings, extrusions, sheet aluminum and steel were to be bought from outside vendors. In addition, standard parts such as nuts, bolts, fittings, valves, etc., and special items landing gear, pumps, electric motors, etc., requiring high skills or equipment were purchased from specialists.

Operations Under the Plan:

At the start of the war production period the Consolidated plan worked very satisfactorily. Quantities on order were not large and suppliers could make deliveries from stock. However, as the program progressed increasing numbers of shortages developed and the expediting department became overloaded.

Changes to the Plan:

Early in the war program the Material Department was organized functionally in three sections, Purchasing, Material Control and Stores. Production Control issued the production schedule to the material

Control Section which then placed orders with the Purchasing Section. The Purchasing Section bought the material. When the material was received the Stores Section took control and issued the material to the shop on Production Control's schedule. The buyer in the Purchasing Section was responsible for the material until it was received at the contractor's plant. After it was discovered that the Bill of Material was not reliable, the shop usage system of purchasing was started.

As difficulties increased it became apparent that no one was responsible for anything when operating the functional organization. As a result of careful study an entirely new concept of a material procurement organization was worked out having vertical rather than horizontal divisions. In effect there were not one but eight material departments under the chief. Each one of the eight division heads was completely responsible for every item in his particular classification and nothing else. He alone was responsible for every phase from the initiation of the purchase request to the actual issue of the material to the line. This clean cut responsibility made it possible to apply the new incentive earnings plan to material department personnel, which still further improved operations - eliminating line stoppages and cutting inventory in half, while production doubled and material became ever more critical. See Business Research Studies, No. 31, Vol. xxxi, No. 2., July 1944, entitled "Materials Management" by Howard T. Lewis and Chas. A. Livesey of Harvard Business School for a more detailed presentation of Consolidated's solution of this most important problem.

Every attempt was made to operate with minimum inventories. A detailed tabulated list was made each month of every item in stock, which indicated past months consumption, actual inventory and standard inventory. The inventory standard was established on the basis of scheduled production requirements for a fifteen, thirty, forty-five, or sixty day period depending upon the nature of the item. This tabulation was reviewed with the Purchasing, Stores and Material Control personnel concerned for reasons and corrective action necessary on unbalanced items. The maintenance of inventories at a standard level was a plus item in the calculation of incentive earnings. The cost of shortages was a negative item in the incentive earnings calculations to avoid production hold-ups by over-zealous inventory reduction. As a result of production experience and the new control plan, lead time was reduced 50% without line stoppage.

The shortage of material, inventory restrictions and information necessary to support allocation requests necessitated a larger expansion of the Material Department than was expected. The Expediting

Department was abolished and the work was taken over by the buyers. Local offices were established throughout the East to make personal contacts for the buyers with vendors behind schedule. Material representatives also contacted Aircraft Scheduling Unit in Dayton and War Production Board in Washington and maintained offices in these cities.

Difficulties Encountered:

Early in the war period, material shortages were the greatest difficulty, however, under the C.M.P. (Controled Materials Plan) in 1943 the B-24 priority position eased the material situation.

Throughout the whole war period the obsolescence of material and parts by engineering changes was the greatest single bottleneck. Many engineering changes required the procurement of material or parts on very short notice and superhuman effort by the eastern expediting offices as well as A.S.U.

Many shortages of material or parts, although not delaying airplane delivery, were relieved out of station on the assembly line at great manhour cost. Substitutes for forgings were hogged out of bar stock, valves and fittings were made in Consolidated's machine shop, and the shortage of aluminum rivets became so great that the contractor had to procure machine tools and make rivets in the shop.

Recommendations:

1. An Army sponsored standardization program for common items such as electric motors, hydraulic pumps, valves, fittings, extrusions, etc. The hydraulic fitting condition is an example of the difficulty which non-standardization can cause and the impractibility of attempting to standardize after mass production has started. Provision should be made so that standard item manufacturers give licenses to manufacture and drawings to other potential producers when requirements exceed their production capacity.

2. As an aid in starting production in a national emergency the Government should maintain a stock pile of aircraft materials. This stock pile should provide for at least 150 planes of each model for which M-Day peak acceleration is planned. It is believed that the experience gained in World War II will enable a plant to accelerate production in time of national emergency much more rapidly than raw materials can be made available.

3. In time of national emergency the procurement of aircraft should be done by one agency of the Government thus eliminating the dual material inspection now required by Army and Navy. At

the present time a contractor having Army, Navy and commercial work has three segregations of material. If the bulk of the work in hand happens to be commercial when an emergency arose the stock pile of material on hand under present inspection regulations could not be used for military airplanes.

4. The time table for selection of spares must be moved up if the Army anticipates having replacement parts concurrent with airplane deliveries. The detail parts program on items not manufactured in the contractor's plant requires simplification and elimination of competition between the services and the contractor for the same item.

GOVERNMENT FURNISHED EQUIPMENT

Summary:

The B-24 airplane produced at Consolidated, San Diego, comprised some 400 items of Government Furnished Equipment. There were occasional shortages where special expediting action was required, but in no case during the entire five year period was it felt that such shortages retarded production to any appreciable extent.

The Plan:

Consolidated planned in the early stages of the program to maintain a separate inventory with separate stock rooms with a supervisor reporting directly to the Chief of Material. However, as production was increased serious problems of procurement, issuance, accountability, etc., appeared and at this time the GFE unit was separated from Material Control and was in effect its own boss, working directly with the A&F and reporting as occasion demanded, only to the Division Manager.

Experience in Operation:

This plan for handling GFE required a large force in addition to that employed in handling CFE items. Because of the different methods of issue and control, confusion grew and shop personnel efficiency dropped. For instance, connector plugs of the same type and stock number were issued as CFE and also as GFE which resulted in the worker never knowing exactly what part was to be used, and

if breakage occurred, it was practically impossible to determine whether to charge the GFE or CFE account. This example was typical throughout the program and difficulty to control. So much so in fact, that the contractor in 1944 was required to reimburse the Government $500,000 for materiel unaccounted for. An effort was made by Consolidated throughout the program to "sell" the AAF the idea of paralleling their own issuance and accountability system, however, the personnel responsible for these decisions apparently were not aware of the production problems regarding GFE and never allowed a change in procedure.

Recommendations:

The experience with the GFE system as it existed in the past war has caused Material Department personnel to strongly recommend that, in a future emergency, GFE as such be abolished except in the case of highly specialized items such as radar. If this cannot be done, a change in accountability must be made to allow the contractor to parallel his own system of procurement issuance and control, i.e. deliver the GFE material to the contractor's plant and collect for same at that time, thereby eliminating the accounting system which was so elaborate and caused so much confusion.

MANPOWER

Summary:

Consolidated, like other airframe plants on the West Coast, found it difficult throughout their production acceleration period to recruit and retain sufficient skilled employees to adequately man the program. Because of the rapid expansion, shortages of these various skills did exist from time to time, nevertheless an actual shortage of manpower in overall numbers was not a threat to production during this past acceleration period. However, the company in 1942 had to turn to greater subcontracting and the establishment of feeder shops, as recruitment at this time became difficult and many of those already employed were leaving because of the lack of sufficient housing and the visible negative attitude of the community. In addition, pre-employment courses, apprentice training through adequate supervision within the factory, and trade extension courses in nearby public schools, supervisor incentive plan (outline attached) were inaugurated to increase the efficiency of the employee in order to meet the ever increasing schedule with a steady decrease in personnel.

The Plan:

Because of the AAF's inability, due to lack of appropriations, to let large production contracts in 1940, and because of the continual changing of schedules subsequent to this time, planning on all phases was necessarily a process of evolution.

Based on their previous experience, the company estimated that 25,000 employees would be required by November 1941. This was an increase of approximately 12,000 in a 12 month span over the number then employed by the company on Navy and British contracts.

Actual hiring was to be based on shop requisitions. In view of the apparently adequate labor market, hiring specifications were relatively high although no trade tests were ever used, and no training program was contemplated.

A vigorous up-grading program within the company was to supply the additional supervisors and foremen needed for the expansion period, and two shifts of 50 hours per week were felt necessary on all projects.

As noted elsewhere in this report, the company, due to the lack of industry in the San Diego area prior to the emergency, was dependent to a large extent on in-migrant workers and Aircraft Trade schools, etc., throughout the country to supply the necessary personnel.

The Labor Supply:

San Diego, California lies directly on the Pacific coast, 130 miles south of Los Angeles and 17 miles north of the Mexican Border, and together with adjacent communities consisting mostly of farmers and tropical fruit growers, comprises San Diego County with a total population in 1940 of 289,348. This population, exclusive of 150,000 military personnel, gradually rose to 415,375 in 1944, the year of peak production at Consolidated.

Inasmuch as San Diego had not been an industrial center prior to 1935, the year Consolidated moved its facilities to this city, the company from the beginning was largely dependent upon in-migrant workers to man the production program. The major industries of the area at this time were fishing, boat building, and trade associated with tourists. Considerable income was also derived from the large Naval establishments in the area. As the result of these conditions, the skill level was low and metal working was practically non-existent. The general education and intelligence on the other hand is rated as well above the average of other cities of comparable size in the United States.

As the emergency program expanded, many new Army, Navy, Marine Corps training stations and staging areas were installed in and around this community. This personnel with its dependents added greatly to the ever increasing problem of housing the defense worker and definitely hindered the recruiting of new workers from outside the area.

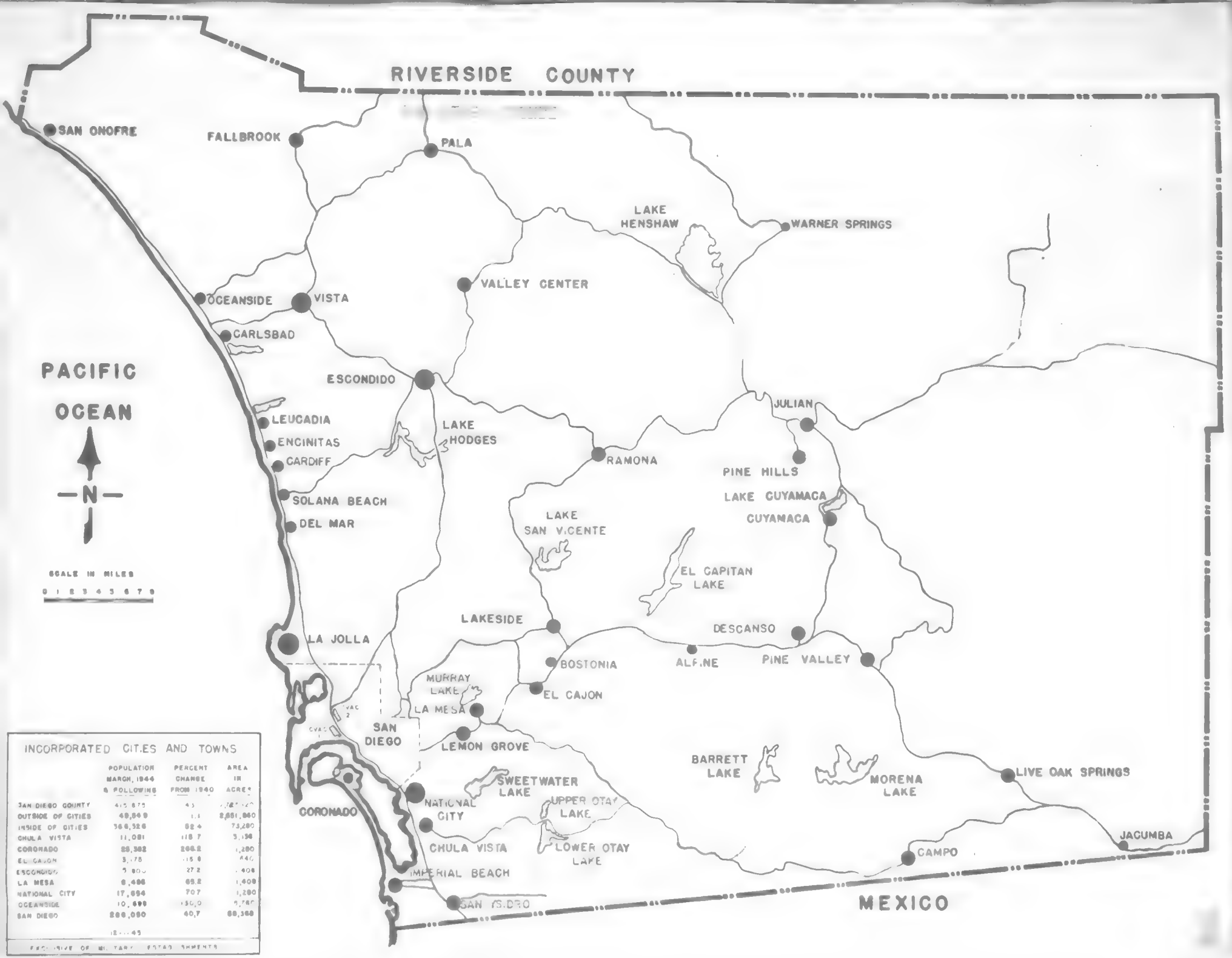
Recruitment and Labor Build-up:

The labor forces at San Diego were built up to a peak of 45,532 employees in November of 1942. Hiring was actually started for B-24 production exclusively in November 1940 when the company had approximately 13,000 people on its payroll, who were working primarily on flying boats for the U. S. Navy. This increase of 32,000 people in a 24 months span, coupled with a substantial rate of turnover, caused the hiring rate at Consolidated to reach as high as 1600 in one week. The average during the years 1942 and 1943, however, was approximately 500 per week, dropping sharply in December 1943. The rate and total employment dropped steadily until peak production was reached in May 1944. The company had at this time 31,113 employees on all production contracts.

Contrary to possible expectations, peak employment was registered sixteen months before peak production of 270 airplanes per month. This was due to lack of prior knowledge and detailed planning and to the time required to train the organization in doing the job. While general improvement was being shown on the learner's curve, moving assembly lines were installed, and subcontracting and feeder plant operations built up to a peak at which 60% of the total man-hours were expended off site.

As noted above, the recruiting of necessary personnel for the expanding B-24 production program started in November 1940 for peak production of 35 airplanes per month with a total of 25,000 people by November 1941. It seems pertinent at this point to record the frequently made observation that a plant employing more than ten to twelve thousand people is too large for efficient operation and the necessary standards of morale, and particularly in the case of the many unstable and unsatisfactory conditions imposed by a war emergency.

The labor supply at this time was considered adequate, but because of the lack of major industries in the area in the past years, a large percentage of the personnel was to be recruited outside the community. The county map following shows clearly the character of the back country areas and the almost complete lack of any labor market adjacent to the city itself. Concentration locally was on skilled and semi-skilled men principally employed in automotive services and allied fields.



INCORPORATED CITIES AND TOWNS

	POPULATION MARCH, 1946 & FOLLOWING	PERCENT CHANGE FROM 1940	AREA IN ACRES
SAN DIEGO COUNTY	415,875	43	2,782,720
OUTSIDE OF CITIES	49,849	1.1	2,681,860
INSIDE OF CITIES	366,526	82.4	73,280
CHULA VISTA	11,081	118.7	5,156
CORONADO	28,382	296.2	1,280
EL CAJON	5,475	115.8	440
ESCONDIDO	5,800	27.2	1,408
LA MESA	8,486	65.2	1,408
NATIONAL CITY	17,694	70.7	1,280
OCEANSIDE	10,698	130.0	9,780
SAN DIEGO	286,080	40.7	88,368

EXCLUSIVE OF MILITARY ESTABLISHMENTS

This source proved very valuable to the company, but by early 1941 very few were left and the contractor turned to Aircraft Trade schools throughout the country in an effort to supplement this diminishing source of supply. This source likewise proved very valuable and furnished many good men who later were used in a supervisory capacity not only in San Diego, but in the company's other plants that later produced B-24's.

By late 1941, the contractor had been called upon to increase his production from 35 to 100 airplanes per month, and in order to meet this schedule, the employment estimates were set at a total of 35,000 by November 1942.

Realizing that the Aircraft Trade schools could no longer supply the demand, the company with cooperation of Government and local schools established a vigorous program to train the in-migrants and the ever increasing number of local women that were being employed. To aid this program the company sent some of its top supervisors to these schools as instructors.

By the time this program was underway, the United States had entered the war and production schedules had skyrocketed. This growing requirement coupled with the personnel losses as increasing numbers of young men volunteered for or were inducted into the armed services caused the company to abandon all estimates of new hires and adopt the practice of hiring as rapidly as possible any and all people who would come to the San Diego plant.

As indicated by the attached charts, all estimates that were made by the company as the result of this policy were met or exceeded until the latter part of 1942 when the hires could no longer replace the "quits". At this point the company turned to outside feeder plants and increasing the amount of subcontracting in order to get the job done.

Training:

In the beginning of the B-24 production program in November 1939 Consolidated recruited the majority of its personnel from aircraft trade schools and their skilled and semi-skilled help from automotive services, etc.

As the production program accelerated, these sources were unable to supply sufficient people, and Consolidated started participating in Government sponsored programs which had been established with the cooperation of the local school system. The company sent some of its best supervisors to these schools as instructors. Other

companies in the area did likewise, and through this cooperation 100,000 people were trained for aircraft work. The main handicap to this program was that the worker or those desiring work were required to train on their own time. To overcome this handicap, the company in the summer of 1942 started sending newly hired employees to these schools where they secured training on company time. This method proved satisfactory, and was continued throughout the program.

The school finally moved on site as a more intensive program was started to develop skills, with definite training of four weeks duration in fabrication, assembly, inspection, and general courses.

Recruiting of engineering personnel was aided by western colleges such as Stanford, California, Modesto and Denver. Students in these schools were given training largely by Consolidated personnel in aircraft problems and company methods before they reported to San Diego for work. The program required eight weeks for 200 engineers, and six weeks for 800 draftsmen, and those were paid a nominal salary during the training period.

On the day of induction the new employees were given a lecture for one-half hour and then personally conducted to their jobs and introduced to their new supervisors. On the second day following the same new group had another lecture of an hour and a half. The final two hour lecture and discussion was given the following day. Stretching the induction program over the period of actual indoctrination proved very much more effective than the original practice of giving the employee a half day of concentrated advise and assistance before in most cases he even knew what the inside of the plant looked like.

Extensive up-grading programs were carried on from the beginning of the training program. Large scale voluntary training was sponsored by the company and was well received by one out of seven employees, only 20% of whom were female.

The special supervisory training section conducted courses in Job Instruction Training, Job Relations Training, Job Methods Training, Foreman Conferences, Supervisory Development, the B-24 airplane, and a Safety Course which proved very popular. The course on the B-24 airplane always had a waiting list of 300. The classes were standardized at 40 persons and the course ran 18 weeks at four hours per week.

On the whole, it is felt that the training program was entirely adequate. As many as 5400 employees were in training at one time. A total of 107,000 were trained by the Education Section. Training requests came from top management, individual departments,

and other programs were originated by the Training Section as the occasion demanded. The fact that requests for training were continually received, and repeated requests from the same departments for the same type of course indicates that the training program was successful.

Work Week and Shift Distribution:

As previously noted, the work week in November 1940 consisted of 50 hours on two shifts. In October 1941, however, a two shift 45 hour week became possible because of the large influx of workers. In November 1941 the schedules began to rise sharply and the company changed to a two shift 53 hour week. This schedule was not entirely satisfactory to meet the demands and utilize the floor area, and as a consequence, in March 1942 a three shift 48 hour week was established. This corresponded to hours worked by other industries in the area and was believed to be the most suitable work pattern. It is doubtful if an increase in hours per week would have been advantageous in view of the fact that over 40% of the total labor force and 50% of direct labor was female.

The shift distribution remained fairly constant throughout the acceleration period. Approximately 60% were on first shift, 38% on second shift, and 2% on third shift.

Wage Rates:

Comparison of wage rates paid by Consolidated with those paid by other plants in the same area and same industry was very favorable, and therefore low rates were not considered by the company to be a serious handicap. A small amount of the total turnover, however, was believed attributable to slightly higher rates paid by shipbuilding and construction industries. There was no "pirating" of any consequence.

Worker Morale:

In general, the morale of the workers was high in the face of the many adverse conditions existing in a city which has more than doubled its working population in a comparatively short time. The company offered complete services to assist employees in securing housing and transportation, and maintained a special board within the plant to aid in various problems associated with rationing. An extensive recreational program was undertaken, seven cafeterias were built to provide hot nourishing food for the workers, counseling service was instituted to aid female employees in solving problems, and child care centers were sponsored by the company to

to assist working mothers. In other words, the company attacked every problem that arose in connection with maintaining high morale among its employees. However, the many adverse factors had the inevitable cumulative effect and morale broke after the production peak was reached. The rate of both hires and quits went off with increasing rapidity, and the fall in direct workers interfered with production. All possible measures to combat this situation were strenuously prosecuted without accomplishing any very satisfactory results.

Labor Relations:

The company never encountered any serious labor difficulties and through its effective Industrial Relations Department maintained a consistent and progressive labor relations policy. A union contract was signed in June of 1941 and through active cooperation with heads of this organization the company was able to maintain an enviable record of no shut-downs or minor work stoppages during the entire emergency.

Utilization of the Working Force:

The increase in productivity at Consolidated, San Diego, by careful planning and training was consistently being improved. The proof of this can be seen in the attached chart showing that in January 1942, the direct manhours per pound was 5.31 and steadily decreased until June 1944 when the direct manhours per pound was .48, which represents a 1000% improvement in a short 30 month span.

The company used its full share of marginal workers. In cooperation with the city and county schools, hundreds of minors were used both on a part-time and full-time basis. Through the physical placement program the company was able to utilize the service of thousands of handicapped, physically limited, and elderly employees. Approximately 700 service personnel from surrounding army camps were also employed at one time. Upwards of 1500 Navy men on pass were employed at peak with great profit to both the men and the company. They worked on the single shift, cash payment basis, doing all sorts of heavy work throughout the plant. This source was cut suddenly without notice by a Naval District Order putting Consolidated plants out of bounds for all Naval personnel. The company was unable to secure any relief from this order. Negroes were hired for practically all types of jibs and in such quantity as was available.

Labor Turnover and Absenteeism:

The absentee rate of this company was consistently lower than the average rates of the airplane industry. For the period March 1943 through December 1944, the rate for this company was 5.5 while the rate for other aircraft companies in Southern California was 6.5.

Turnover rates on the other hand were slightly higher than the average industry rate. For the period from January 1943 through December the company's turnover rate was 7.8 as compared with 7.4 for the industry. This condition was due in part to the community spirit and a definite shortage of housing. Military separations also took their toll. As many as 1800 personnel were separated in one month for this reason alone, while more than 18,000 men passed through the plants of the San Diego Division into the armed services. At a most conservative estimate a month's production loss is involved in the change of a direct worker, and the intangible losses are beyond computation. Later in the program a pretermination interview was established in an attempt to salvage employees who were quitting, thus many employees were retained by discussion and solution of their personal problems.

Community Factors:

No evidence is available to suggest that the community of San Diego as a whole took positive action to make Consolidated Management and its wartime personnel part of the community. This feeling made the recruitment and retention of its personnel most difficult throughout the program.

Early in 1942 housing became a serious threat to production as new people could not be recruited and many of those already employed were leaving because adequate housing for their families did not exist. Because of the existence of many large Army and Navy establishments in the area and the campaign of these services to secure housing for their personnel, private housing and early federal housing programs did not relieve the situation as far as Consolidated was concerned. To alleviate this condition, Consolidated, through its Washington representatives, was able to secure approximately 7500 additional federally sponsored homes and 900 trailers for exclusive use of the aircraft companies in the area. The construction of the homes over a period of two years helped materially, but never relieved the congestion, as personnel continued to terminate as late as June 1944 because of this condition.

Transportation:

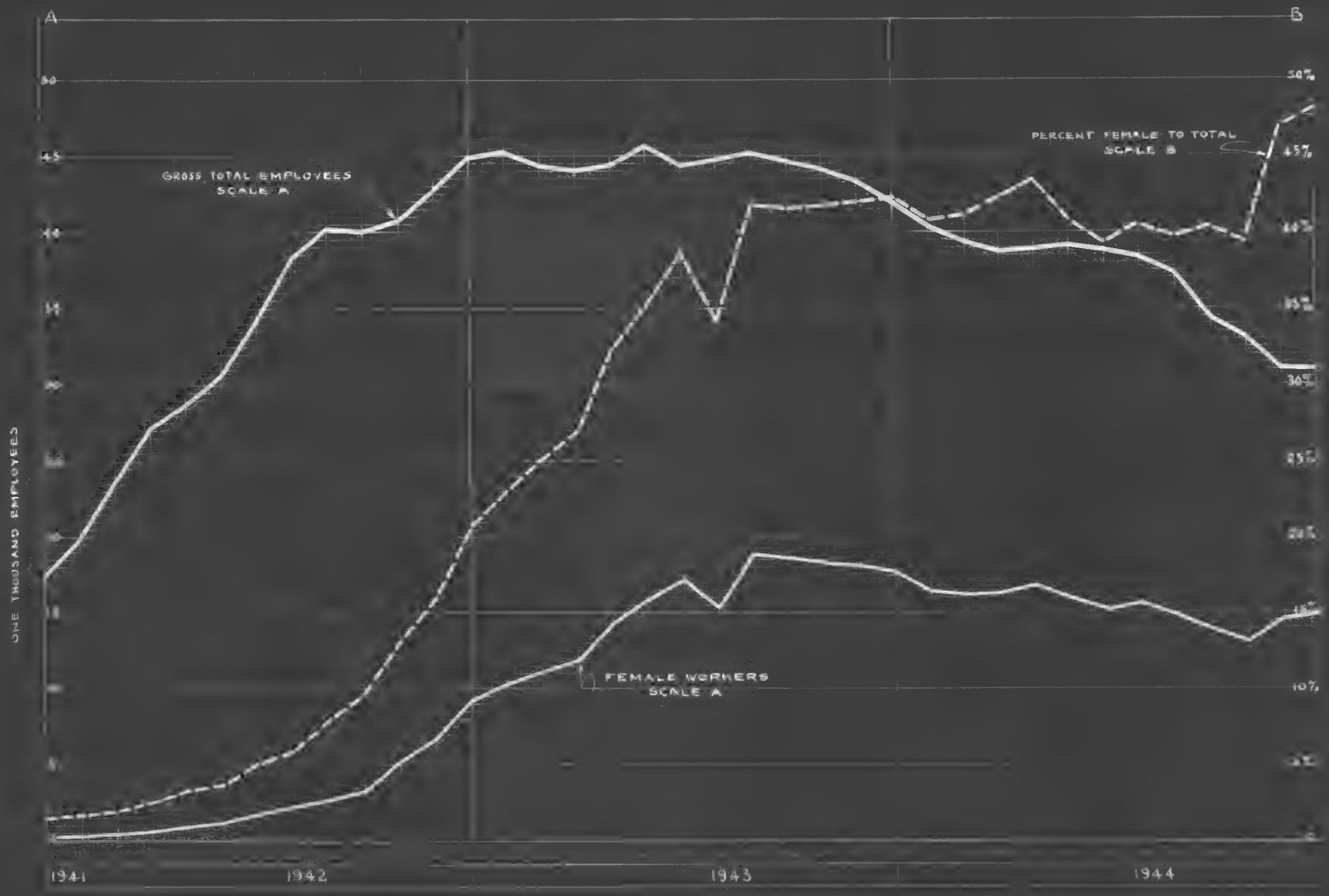
Due to the central location of the company plants, the existence of adequate parking facilities, the full cooperation of the local

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION

	Direct Man Hours		Direct Man Hours Per Unit								Time Cycle			
	Actual	(1000) Cum	Cum Plane No.	On Site	% O.P.	% Comp. O.P.	Entire Plane	Unit Airframe Weight	Direct MH/LB	Cum Plane No.	Time Cycle in Days	Last 15 Days	16 to 45	46 to 75	76. to 105
June 41	58	169													
July	80	249													
Aug.	77	326													
Sept.	144	470													
Oct.	172	642													
Nov.	633	1,275													
Dec.	1,684	2,959													
Jan. 42	2,762	5,721	7	90,000	16.0	84.0	107,143	20,171	5.31						
Feb.	2,302	8,023	63	80,000	16.0	84.0	95,238	20,171	4.72						
Mar.	3,047	11,670	134	60,000	16.0	84.0	71,429	20,171	3.54	134	89	27.0%	73.0%		
Apr.	2,524	14,194	213	50,000	16.0	84.0	59,524	20,171	2.95						
May	2,668	16,862	300	45,000	16.0	84.0	53,571	20,171	2.66						
June	2,754	19,616	394	40,000	16.0	84.0	47,619	20,171	2.36	394	55	44.2%	49.3%	6.5%	
July	2,853	22,469	494	35,000	16.0	84.0	41,667	20,171	2.07						
Aug.	2,676	25,145	602	30,000	16.0	84.0	35,714	20,171	1.77						
Sept.	2,660	27,805	718	28,000	16.0	84.0	33,333	20,171	1.65	718	48	49.9%	48.6%	1.5%	
Oct.	2,669	30,474	847	24,000	16.0	84.0	28,571	20,171	1.42						
Nov.	2,680	33,054	974	22,000	16.0	84.0	26,190	20,171	1.30						
Dec.	2,633	35,687	1,114	21,000	23.2	76.8	27,344	20,171	1.36	1,114	48	49.9%	48.6%	1.5%	
Jan. 43	2,617	38,304	1,234	19,000	23.4	76.6	24,804	23,149	1.07						
Feb.	2,362	40,666	1,382	18,000	29.7	70.3	25,604	23,149	1.11						
Mar.	2,488	43,154	1,534	16,500	31.8	68.2	24,154	23,226	1.04	1,534	48	49.9%	48.6%	1.5%	
Apr.	2,349	45,503	1,696	16,000	28.1	71.9	22,253	23,226	.96						
May	2,366	47,869	1,873	15,000	29.6	70.4	21,306	23,228	.92						
June	2,433	50,302	2,063	13,900	31.7	68.3	20,351	23,584	.86	2,063	48	49.9%	48.6%	1.5%	
July	2,446	52,748	2,265	13,500	33.0	67.0	20,149	23,584	.85						
Aug.	2,300	55,048	2,479	12,000	26.5	73.5	16,328	23,584	.69						
Sept.	2,342	57,390	2,709	11,800	27.5	72.5	16,276	23,278	.70	2,709	48	49.9%	48.6%	1.5%	
Oct.	2,531	59,921	2,954	11,600	27.0	73.0	15,890	23,278	.68						
Nov.	2,311	62,232	3,204	10,740	31.7	68.3	15,725	23,278	.68						
Dec.	2,296	64,528	3,459	10,350	33.0	67.0	15,448	23,124	.67	3,459	44	49.9%	50.1%		
Jan. 44	2,138	66,666	3,712	9,400	35.0	65.0	14,462	23,124	.63						
Feb.	2,008	68,674	3,966	8,270	38.0	62.0	13,339	23,124	.58						
Mar.	2,205	70,879	4,236	8,040	37.0	63.0	12,762	22,949	.56	4,236	44	49.9%	50.1%		
Apr.	1,856	72,735	4,487	7,989	35.5	64.5	12,386	22,949	.54						
May	1,879	74,614	4,757	7,600	35.0	65.0	11,692	22,949	.51						
June	1,803	76,417	5,017	7,000	36.0	64.0	10,938	23,010	.48	5,017	44	49.9%	50.1%		

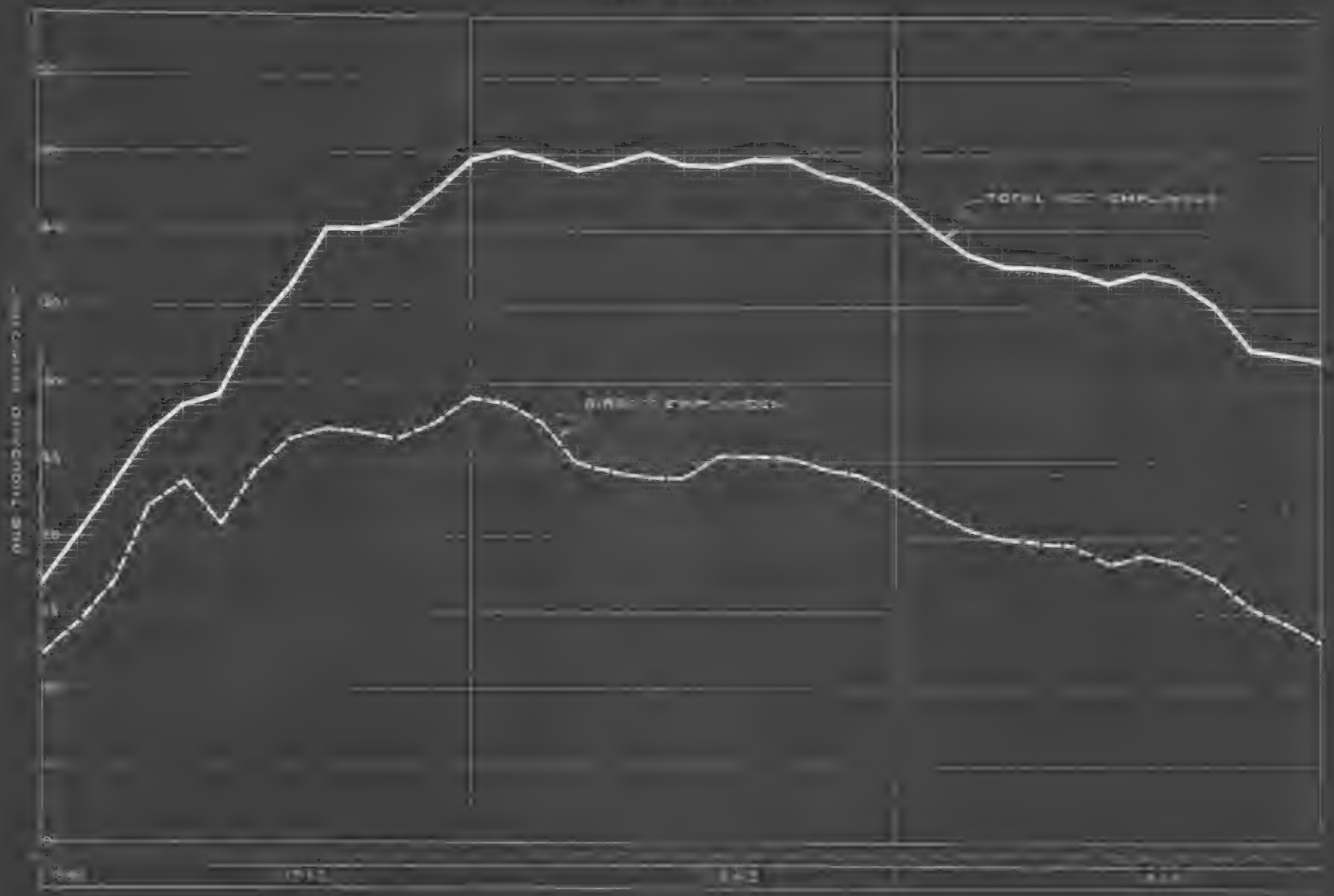
CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

TOTAL VS. FEMALE EMPLOYEES
ALL MODELS



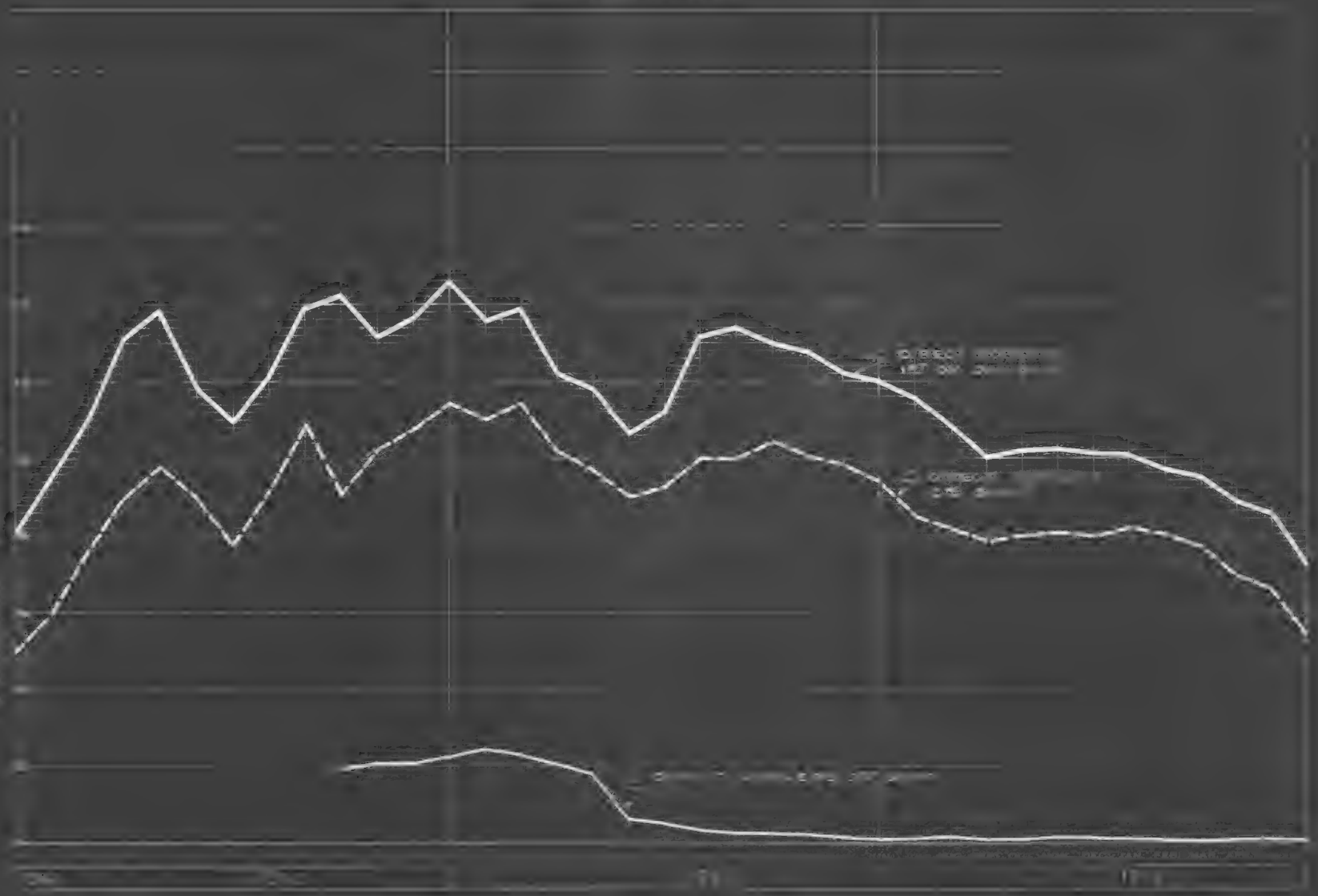
CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

TOTAL AND DIRECT EMPLOYEES
ALL MEMBERS



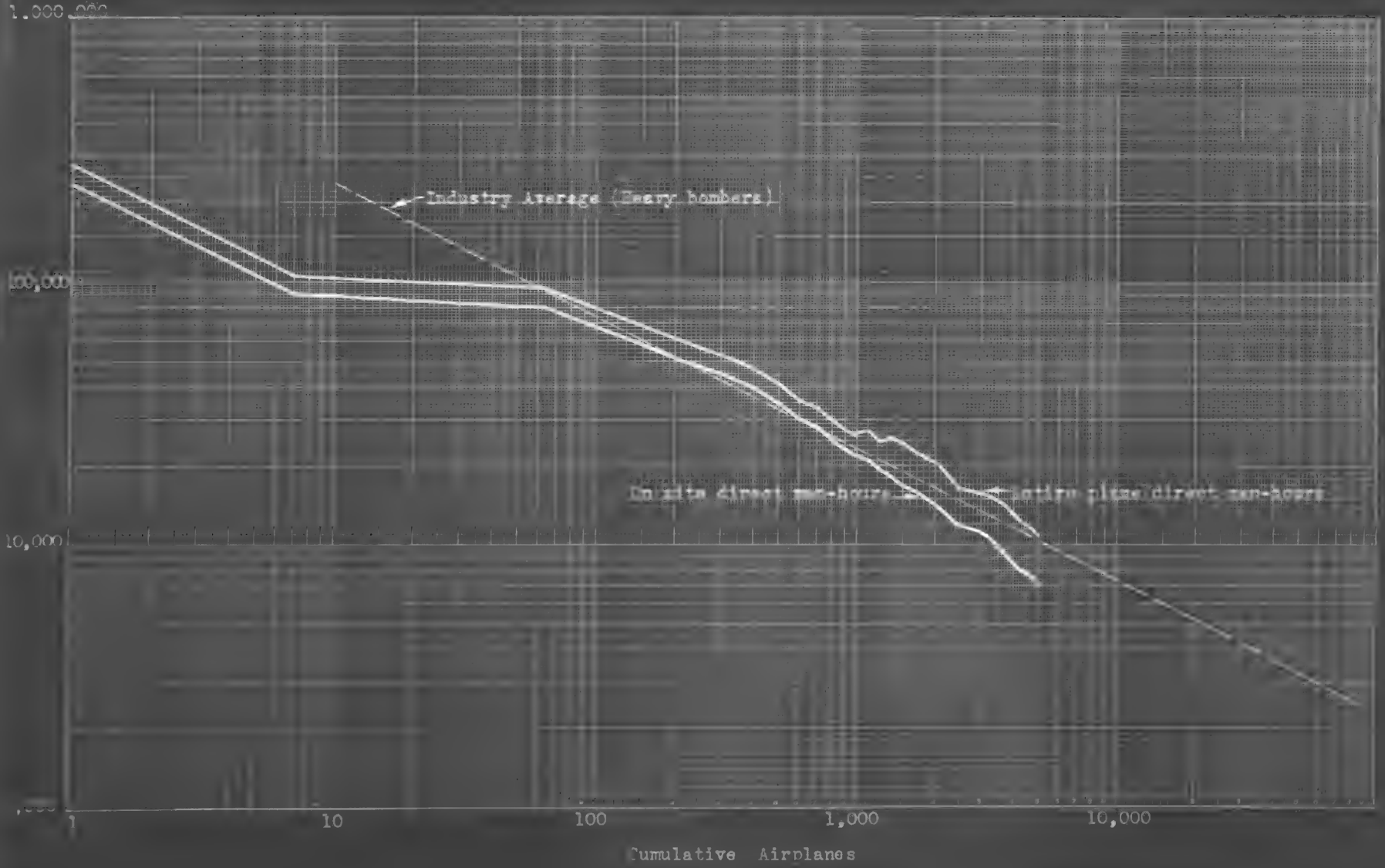
CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

DIRECT WORKERS SHIFT DISTRIBUTION



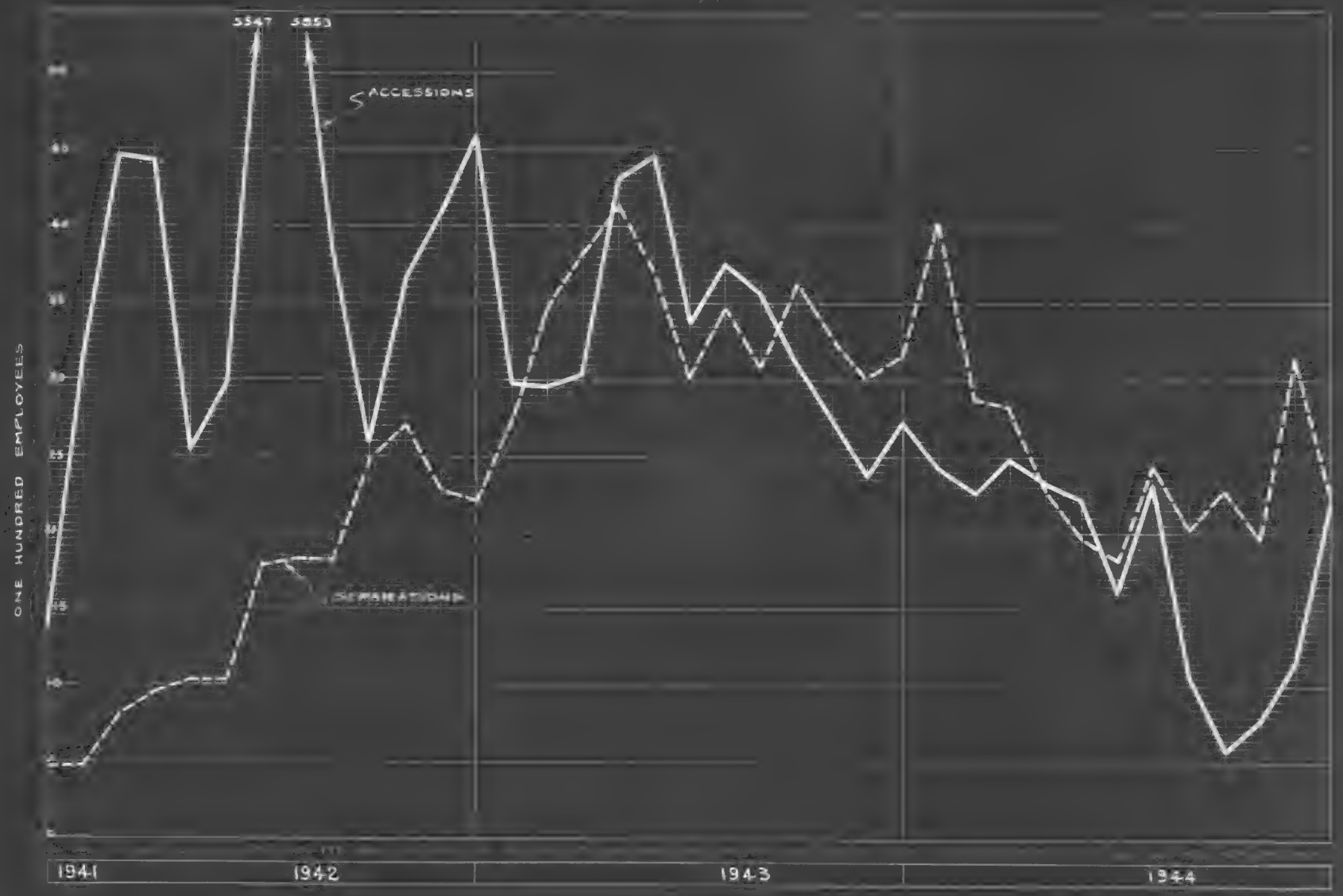
Consolidated Vultee Aircraft Corp.
San Diego Division

B-24D Direct Labor Progress Curve



CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO DIVISION

TURNOVER
ALL MODELS

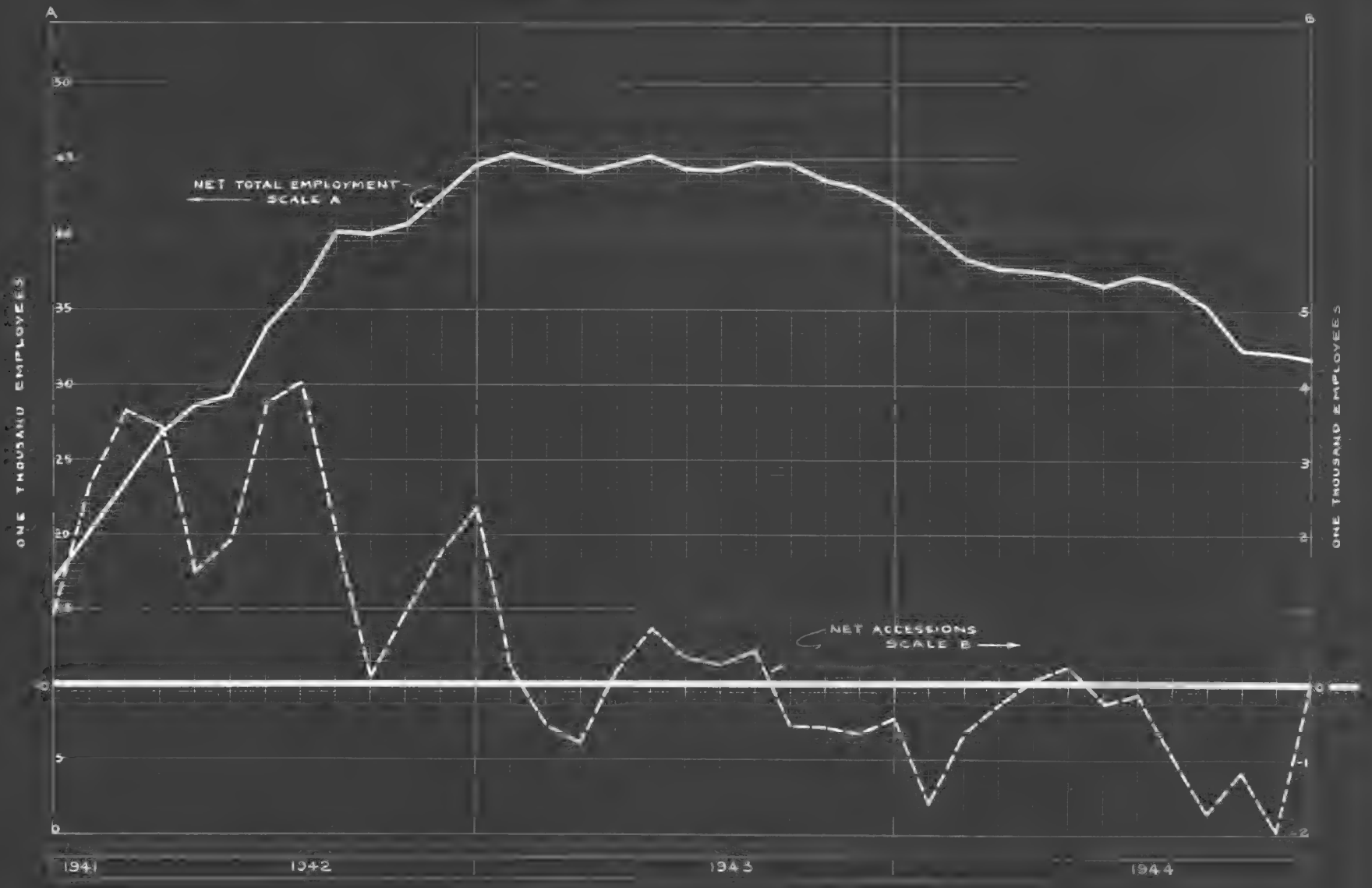


Employment & Turnover

	Gross Employment				Net Employment				Turnover						
	Total		Female		Total	Direct		Indirect	Accessions		Separations		Net Access		% O.P.
	No.	Net Access	No.	% Total	No.	No.	% of Total	No.	Actual	Rate	Actual	Rate	Actual	Rate	
June 41	17,298	↑ 799	259	1.5	16,872	12,225	72.5	4,652	1374	7.9	465	2.7	↑ 909	↑ 5.2	-
July	19,953	↑ 2655	331	1.7	20,016	14,391	71.9	5,625	3112	15.6	464	2.3	↑ 2648	↑ 13.3	-
Aug.	23,705	↑ 3752	459	1.9	23,265	16,980	73.0	6,285	4458	18.8	809	3.4	↑ 3649	↑ 15.4	-
Sept.	27,088	↑ 3383	682	2.5	26,661	22,029	82.6	4,632	4434	16.4	967	3.6	↑ 3467	↑ 12.8	-
Oct.	28,669	↑ 1581	959	3.3	28,553	23,670	82.9	4,883	2530	8.8	1033	3.6	↑ 1497	↑ 5.2	-
[illegible]	30,584	↑ 1915	1,142	3.7	29,297	20,847	71.2	8,450	2958	9.7	1043	3.4	↑ 1915	↑ 6.3	-
[illegible]	34,222	↑ 3638	1,748	5.1	33,786	24,369	72.1	9,417	5547	16.2	1795	5.2	↑ 3752	↑ 11.0	-
Jan. 42	38,240	↑ 4018	2,267	5.9	36,255	26,382	72.8	9,873	5853	15.3	1843	4.8	↑ 4010	↑ 10.5	16.0
Feb.	40,141	↑ 1901	3,228	8.0	40,063	27,040	67.5	13,023	3853	9.6	1825	4.5	↑ 2028	↑ 5.1	16.0
Mar.	40,004	- 137	3,865	9.7	39,996	26,781	67.0	13,215	2599	6.5	2498	6.2	↑ 101	↑ 0.3	16.0
Apr.	40,706	↑ 702	5,361	13.2	40,611	26,332	64.8	14,279	3653	9.0	2700	6.6	↑ 953	↑ 2.4	16.0
May	42,598	↑ 1892	6,752	15.9	42,517	27,447	64.6	15,070	4076	9.6	2288	5.4	↑ 1788	↑ 4.2	16.0
June	44,963	↑ 2365	9,291	20.7	44,641	29,076	65.1	15,565	4590	10.2	2215	4.9	↑ 2375	↑ 5.3	16.0
July	45,238	↑ 275	10,444	23.0	45,244	28,676	63.4	16,568	2976	6.6	2748	6.1	↑ 228	↑ 0.5	16.0
Aug.	44,465	- 773	11,179	25.1	44,737	27,557	61.6	17,180	2955	6.6	3477	7.8	- 522	- 1.2	16.0
Sept.	44,066	- 399	11,849	26.9	44,037	24,898	56.5	19,139	3039	6.9	3833	8.7	- 794	- 1.8	16.0
Oct.	44,359	↑ 293	14,339	32.3	44,563	24,316	54.6	20,247	4311	9.7	4147	9.3	↑ 164	↑ 0.4	16.0
Nov.	45,531	↑ 1172	15,980	35.1	45,193	23,946	53.0	21,247	4459	9.8	3706	8.1	↑ 753	↑ 1.7	16.0
Dec.	44,423	- 1108	17,192	38.7	44,424	23,929	53.9	20,495	3378	7.6	3017	6.8	↑ 361	↑ 0.8	23.2
Jan. 43	44,706	↑ 283	15,279	34.2	44,345	25,349	57.2	18,996	3761	8.4	3478	7.8	↑ 283	↑ 9.6	23.4
Feb.	45,198	↑ 492	18,909	41.8	44,729	25,582	56.7	19,347	3573	7.9	3084	6.8	↑ 489	↑ 1.1	29.7
Mar.	44,672	- 526	18,580	41.6	44,725	25,238	56.4	19,487	3108	7.0	3634	8.1	- 526	- 1.1	31.8
Apr.	44,113	- 559	18,383	41.7	43,656	24,500	56.1	19,156	2740	6.2	3299	7.5	- 559	- 1.3	28.1
May	43,473	- 640	18,246	42.0	43,211	24,071	55.7	19,140	2375	5.5	3015	6.9	- 640	- 1.4	29.6
June	41,950	- 1523	17,746	42.3	42,066	23,071	54.8	18,995	2724	6.5	3160	7.5	- 436	- 1.0	31.7
July	40,359	- 1591	16,485	40.8	40,130	21,695	54.1	18,435	2438	6.0	4029	10.0	- 1591	- 4.0	33.0
Aug.	39,350	- 1009	16,231	41.2	38,467	20,550	53.4	17,917	2257	5.7	2877	7.3	- 620	- 1.6	26.5
Sept.	38,690	- 660	16,348	42.3	37,776	19,943	52.8	17,833	2487	6.4	2733	7.1	- 246	- 0.7	27.5
Oct.	38,827	↑ 137	16,897	43.5	37,640	19,717	52.4	17,923	2341	6.0	2270	5.8	↑ 71	↑ 0.2	27.0
Nov.	39,036	↑ 209	15,952	40.9	37,335	19,501	52.2	17,834	2218	5.7	1966	5.0	↑ 252	↑ 0.7	31.7
Dec.	38,771	- 265	15,251	39.3	36,603	18,297	50.0	18,306	1617	4.2	1831	4.7	- 214	- 0.5	33.0
Jan. 44	38,445	- 326	15,582	40.5	37,249	18,872	50.7	18,377	2319	6.0	2437	6.3	- 118	- 0.3	35.0
Feb.	37,462	- 983	14,871	39.7	36,720	18,411	50.1	18,309	1055	2.8	2020	5.4	- 965	- 2.6	38.0
Mar.	34,401	- 3061	13,398	40.4	35,192	17,245	49.0	17,947	588	1.7	2292	6.7	- 1704	- 5.0	37.0
Apr.	33,141	- 1260	13,029	39.3	32,367	15,453	47.7	16,914	787	2.4	1955	5.9	- 1168	- 3.5	35.5
May	31,113	- 2028	14,579	46.9	32,106	14,414	44.9	17,692	1155	3.7	3132	10.1	- 1977	- 6.4	35.0
June	31,069	- 44	14,950	48.1	31,732	13,157	41.5	18,575	2203	7.1	2234	7.2	- 31	- 0.1	36.0

CONSOLIDATED VULTEE AIRCRAFT CORP
SAN DIEGO DIVISION

TOTAL EMPLOYMENT - NET ACCESSIONS
ALL MODELS



bus system together with the staggering of hours by the business concerns and other war plants, transportation was never considered a serious factor in the production picture at San Diego.

Recommendations:

In retrospect, the following points must be seriously considered if difficulties encountered in the emergency just past are to be avoided in the future.

1. The services must indicate their future and peak requirements if manpower is to be scheduled accurately.

2. Realistic thinking suggests that any company facing such an expansion program as this should have its employees frozen on the job and barred from military service. Replacement schedules regarding Selective Service must be realistic and based on the company's ability to replace those people taken. Allocation of manpower as a whole should be undertaken to reduce the rate of turnover.

3. Adequate housing must be planned and allocated to the war industries.

4. The Army Reserve system should be broadened to include an industrial staff capable of assisting the manufacturers in the event of a future emergency.

5. Peace-time planning and production must be worked out to provide steady satisfactory employment for the supervisory personnel on whom alone can the required war-time production acceleration curve be based. It should be observed that manpower can not be stored in moth balls.

PRODUCTION CONTROL

Summary:

From the 30th of November 1940 until September 1943 the delivery schedule of the B-24 airplane was revised upward nine times. These schedule changes required new production planning. In the spring of 1941 the Production Planning and Tooling Department was organized and Production Methods Engineers were brought into the plant for the first time. This Department did the production planning throughout the war period and the record of deliveries to the Army indicates the magnitude of the job.

The Plan:

The Production Planning and Tooling Department was divided into Production Control, Production Planning, Tooling and Plant Engineering Groups. A new airplane delivery schedule was broken down into production requirements by weeks and days, and operations, routings, work loads, etc. were planned. The flow of work through the factory was by the lot system, each lot representing a month's production.

Experience in Operation:

By the spring of 1942 the year-old Production Planning and Tooling Department began to function smoothly. The magnitude of the planning done by this Department is indicated by the following description of schedule changes. During 1941 and early 1942 production planning was based on an output of 90 airplanes per month. On 3 March 1942 a new schedule was authorized calling for a peak of 136 airplanes per month by April 1943. The next revision occurred in August 1942 calling for 156 airplanes per month by December 1942. The schedule was again revised 1 September 1942 for a peak of 200 per month by October 1943. On 1 January 1943 the schedule was further revised to call for a peak of 240 per month by October 1943 and later revisions in June and September 1943 increased the schedule to a peak in May 1944 of 269 airplanes per month.

The schedule issued 20 May 1941 with a peak of 100 airplanes per month, this peak being later reduced to 90, should be considered the first schedule which can be definitely associated with war production. Production plans for this schedule were a development of the decisions to incorporate moving production lines together with the breakdown of major components. This plan also involved the use of Plant #2 to reach the goal of 90 airplanes per month. It should be noted that 90 airplanes per month was approximately 1/3 of the production later achieved so that planning, tooling and production control was found to be inadequate for this later production.

The original plan of 90 airplanes per month was based on only a minor amount of subcontracting. The high production rate later attained was possible after the decision to subcontract all major components other than the fuselage and center wing.

The control of raw material and purchased parts into the plant and stockrooms was the function of the Material Department. All materials were purchased to schedules prepared by the Production Control Section. As materials were issued from stores on requisition, all control passed to the Production Control Section.

Both detailed planning and detailed methods for the accomplishment of peak schedules were subject to constant revision during the entire duration of the war. Changes in methods and planning could result from Cost Improvement Proposals submitted either by supervision or members of the working force, through Industrial Engineering recommendations and layouts, or through planning changes made by personnel of the Planning Section. In addition requests from the Army for changes made necessary by combat requirements or the creation of improved accessories at the plants of other manufacturers resulted in an ever increasing stream of changes in detail, assembly, and installation planning.

Changes in the Plant

Scheduling of Army requested changes was accomplished through the MCR system and while these were in great volume, the still greater number of miscellaneous changes resulting from engineering corrections, as well as the methods and planning changes, made necessary the creation of a similar system for recording and scheduling all miscellaneous changes. After difficulty in making change schedules in the production line due somewhat to a lack of coordination with the shop by the Master Scheduling Department, a Master Scheduling Committee was formed. This Committee closely policed and supervised MCR changes and authorized rescheduling where it became apparent that change schedules could not be met without disruption of the assembly line. The volume of miscellaneous changes grew to such an extent that they could not properly be handled with any degree of speed. It was found necessary to schedule such changes after completion of planning and tooling since loads in thetooling shops were such that MCR changes received top priority. To relieve this bottleneck Review Boards for miscellaneous changes were set up to analyze and determine essential requirements with authority to cancel unnecessary changes.

During 1943 as the production rate was accelerating the lot system of manufacturing release created somewhat of a problem. The banks of material or subassemblies in one lot became too great to handle in the storage facilities available and on some items split lots had to be used. Some trouble was caused by the shortage of material also necessitating split lots for the material on hand. To control the lot quantities, the second shift storekeepers (Production Control personnel) inventoried all parts and subassemblies actually on the line and below minimum stock levels and these inventories were posted on IBM equipment. These shortage lists were analyzed by Production Control to determine reasons and to take corrective action. Where unexplained inventory losses hadoccurred the necessary additional orders with advanced schedules were prepared and released to Fabrication or Material Department as required.

SUBCONTRACTING

Introduction:

Prior to 1942 it was Consolidated's policy to subcontract only those items on which other manufacturers had developed special tools and techniques. Such items included exhaust manifold assemblies, engine mounts, and specialized punch press parts and machine shop jobs. In addition certain major components such as pontoons, wing panels, and attaching parts were subcontracted, as a policy, to eliminate the necessity for expansion of plant facilities when long term use of such facilities could not be foreseen.

Even before Pearl Harbor, and stimulated by the European war, the Contractor began to realize the necessity for expansion to cover increasing aircraft demands. And when it became evident in early 1942 that the production acceleration demanded of the company far exceeded its ability to obtain the necessary additional manpower, equipment, and space at the home plant, the decision to expand the subcontracting program was made.

Original Plan:

Subcontracting prior to 1942 averaged approximately 10% of the total airframe manhours, with some exceptional peaks reaching 15% to 20%. However, when the decision was made to expand the program, it was planned to quadruple the amount of subcontracting to approximately 40% of the total manhours.

This was to be done by subcontracting large units basically simple and complete in themselves such as wing leading edges, flaps, ailerons, elevators, rudders, stabilizers, tabs, bomb doors, gun turrets, bulkheads, and pilots enclosures. In addition subcontractors for assembly of power plants and power plant equipment were to be developed.

Subcontractor Selection:

While geographical location had a bearing on the selection of subcontractors, decision to place the business usually centered on manufactoring ability, scope of facility, and labor market availability.

Generally speaking the early sources were well established as reliable aircraft subcontractors and included such companies as Brewster Aeronautical, Long Island, N.Y.; Bell Aircraft, Buffalo, N.Y.; Northrop Aircraft, Hawthorne, Calif.

With the increased aircraft demands of 1942 it became necessary to develop new sources which in general meant the conversion of commercial manufacturers to aircraft facilities, processes, methods and

techniques. These new sources were given more study than previously and their respective managements, facilities and operating conditions closely analyzed to determine to what degree they could be adapted to handle aircraft work.

Operation of the Plan:

Although the original plan was to subcontract specialized items and those that were relatively simple and complete in themselves, which items amounted to approximately 40% of the total plane, it became necessary to subcontract more complicated items to the extent of 46% of the total manhours in late 1944.

The following items were subcontracted at peak production to the companies indicated:

Subcontractor	Location	Item
American Central Mfg.Corp.	Connersville,Ind.	Exhaust Collector
" " " "	" "	Tail Stack
" " " "	" "	Wing Outer Panels
" " " "	" "	Top Deck Assembly
" " " "	" "	Fuselage Top Center Section
Atlas Chromium Plating	Los Angeles, Calif.	Plating Flap Tracks
Baash-Ross Tool Co.	" "	Flap Tracks
Berger Mfg. Div.	Canton, Ohio	Wing Flap Assembly
" " "	" "	Bomb Bay Door
" " "	" "	Stabilizers
Bobrick Mfg. Corp.	Los Angeles, Calif.	Check Valve Assembly
Cal.Carnice,Steel & Supply	" " "	Bomb Hoist Support
Casper Airc. Co.	San Diego, Calif.	Electric Harnesses
Castoloy Corp.of Calif.	Los Angeles, Calif.	Main Entrance Door
Continental Can Co.	" " "	Leading Edges
" " "	" " "	Trailing Edges
Cons.Vultee Airc.Corp.	Nashville, Tenn.	Center Sect. Front Spar
Drayer & Hanson	Los Angeles, Calif. (4)	Scavenging Kits
Engel Airc.Specialties	Escondido, Calif.	Wing Splice Plates
" " "	" "	Elevator Tab Assembly
Essick Mfg. Co.	Los Angeles, Calif.	Main Beam & Hoist
Firestone Airc. Co.	Los Angeles, Calif. (5)	Oil Cells
Gay Eng. Corp.	" " "	Engine Mount Supports
Gemmer Mfg. Co.	Detroit, Mich.	Aileron Gear Unit
" " "	" "	Torque Tube Assembly
" " "	" "	Bellcrank Assembly
" " "	" "	Bellcrank Control System
" " "	" "	Bearing Assembly
General Fireproofing Co.	Los Angeles, Calif.	Pilot Seats

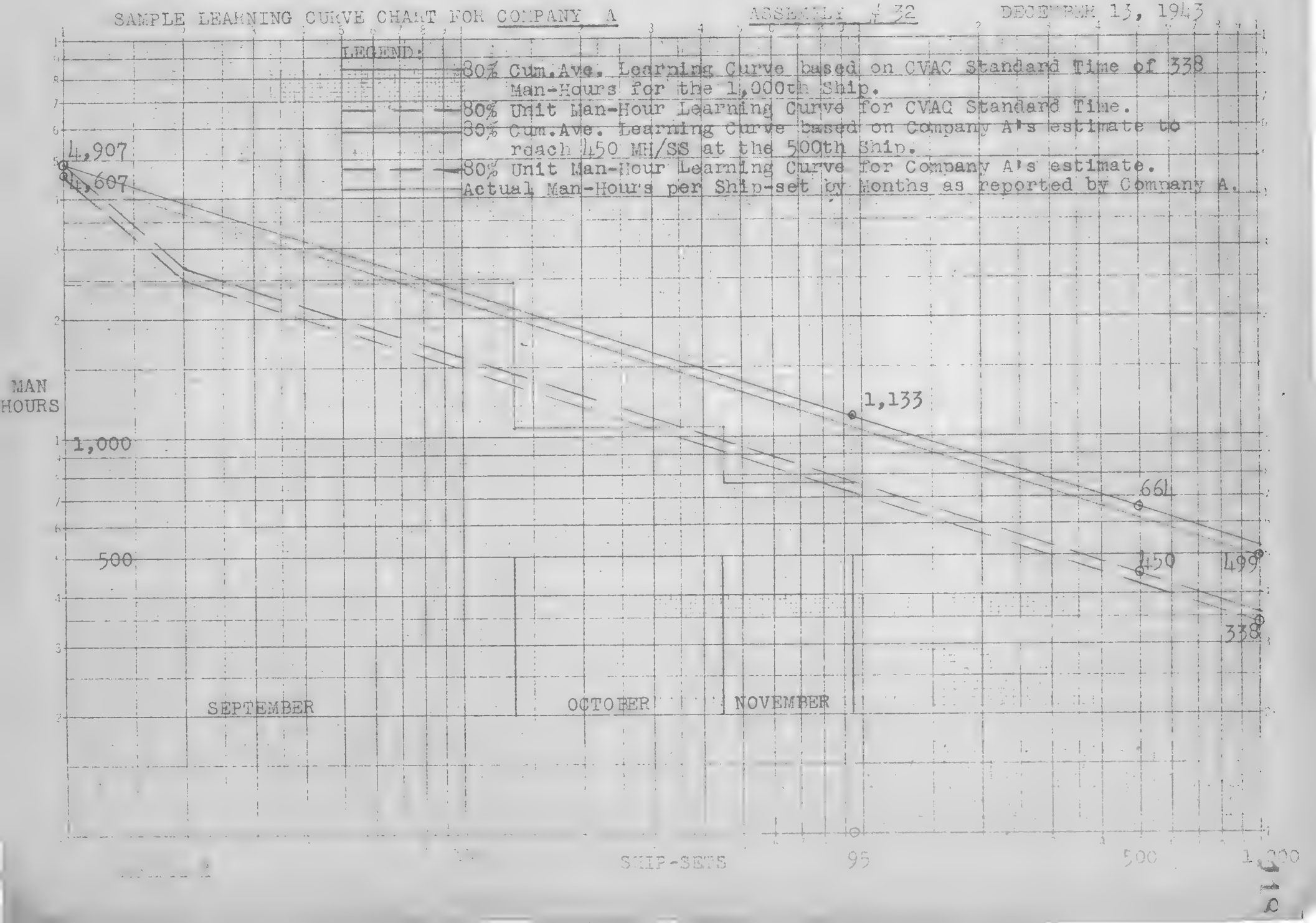
(3)

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO, CALIFORNIA

VENDOR: Company A PART: #32 BID #

REPORTING PERIOD (Month)	SHIP-SETS SHIPPED THIS PERIOD	DIRECT LABOR MAN-HOURS ALLOCATED THIS PERIOD	MEN REQUIRED THIS PERIOD (÷ BY 208)	MAN HOURS PER SHIP-SET THIS PERIOD	CUMULATIVE SHIP-SETS	CUMULATIVE MAN-HOURS ALLOCATED	ACTUAL CUMULATIVE AVERAGE MAN-HOURS PER SET	ANTICIPATED CUM. AVE. FROM COMPANY A's ESTIMATE	REMARKS
September	13.5	33,250	160	2,463	13.5	33,250	2,463	2,129	
October	31.5	33,600	162	1,067	45	66,850	1,486	1,616	
November	50.0	38,100	183	762	95	104,950	1,105	1,133	
TABLE A									

SAMPLE LEARNING CURVE CHART FOR COMPANY A — ASSEMBLY # 32 — DECEMBER 13, 1943



However, after the job was placed in the subcontractor's plant the learning curve of that item in the new location was maintained, observed, and manpower and cost predictions made.

Maintenance of these efficiency or learning curves was made possible through the receipt of manhour reports from the subcontractors. These reports were submitted periodically; weekly, semi-monthly, or monthly, depending upon the company's methods of timekeeping, although the majority of reports were received weekly, the most desirable reporting basis. In those few cases where the subcontractor refused to submit regular reports, personnel from Consolidated would periodically visit the subcontractor's plant and by means of observation, closely estimate the desired data.

The usual manhour report showed three things: (1) The total number of manhours expended on the quantity of assemblies produced during the defined time period; (2) the average number of manhours per ship set allocated to the construction of each completed assembly during this period; and (3) the number of assemblies completed during this period.

From this basic data was charted the learning curve of each assembly in each subcontractor's plant. These charts in turn made it possible to anticipate future performance of the subcontractor, (1) in determining future production costs in terms of manhours; (2) in deriving projected labor loads indicating the number of workers required to meet the production schedule; and (3) in predicting and, consequently, preventing bottlenecks in delivery of assemblies to the prime contractor due to over-optomistic commitments. See following descriptive enclosure.

Organization:

Previous to April 1942 all subcontracting had been handled by the Purchasing Department. On that date, however, a separate subcontract organization was established apart from "Purchasing" to specialize in the procurement of larger units of the airplane. While some items, such as the exhaust collector, engine mounts, and similar units generally procured outside, were also in the Subcontract Department, basically those larger units designed by the prime contractor and which normally would have been built within its own plant, were known as subcontract units. These units were wing panels, leading edges, control surfaces, doors, and sections.

The Subcontract Department as first established consisted of approximately 15 people but was expanded during the years of 1942 and 1943 to a maximum of 197 in January and March of 1944.

Basically this organization consisted of three sections: (1) The procurement and negotiation group, (2) the coordinating section (engineering and tooling liaison), and (3) the control section (statistical). Approximately 80% of the department's personnel were employed on the procurement problems and negotiations, follow-up, and expediting. About 10% of the personnel were required in engineering and tooling coordination, and the remaining 10% used on statistical and control work.

Although each subcontracting head was responsible, execution of contracts was obtained from an officer of the Corporation. All final negotiations and contracts were coordinated very closely with Consolidated's Legal and Treasury Departments.

Personnel employed in the Subcontracting Dept. were generally of a high calibre, being attracted there by the appeal and diversification of the work. As previously indicated this Department stressed the application of business, engineering, tooling, legal, and manufacturing aspects. Experience in such an organization supplemented the monetary salaries paid and was recognized by the employees to be very valuable.

Effectiveness of Subcontracting Program:

Generally, experience with the subcontractors was highly satisfactory, particularly where sufficient liaison was and could be maintained by the companies. Subcontractors' managements aggressively instituted programs for improvement and continually extended themselves to be more efficient and of more service to the prime contractor. In numerous instances the background of the subcontractor was utilized to improve the usual aircraft methods which improvement was passed on to the prime. Thus the exchange of ideas between the subs and the prime at all times proved to be mutually beneficial.

The original reluctance on the part of a subcontractor new to aircraft in establishing fixed prices was shortly overcome when it was recognized that Consolidated's application of the aircraft industry's method of charting manhour data and cost data was sound and that learning curve data not only gave a guide to the subcontractor with respect to manhour cost and rate of manufacture, but that it was also invaluable to him with respect to his financial requirements and in his financial negotiations with the prime contractor. In many instances the application of such manhour and learning curve data was entirely unknown to the subcontractor. Here again the confidence built up and the improved relationship resulting from these statistical studies proved to be mutually advantageous to both sub and prime contractor.

Consolidated's experience indicated that, while it was desirable that the subcontractor be located geographically close to the prime contractor, this was not essential provided that highways or rail facilities

were available for the movement of raw materials and finished parts. In the early stages of subcontracting substantial pools or banks of parts were maintained as insurance against shortages or work stoppages due to transportation difficulties. However, as subcontractors improved their control and handling procedures and as secondary sources were established in other areas, these problems became minimized, which enabled considerable reduction in the size of various banks of parts. Temporary tie up of manufacturing was experienced in only a very few instances, none of which were critical enough to actually retard production.

Conclusions and Recommendations:

The history of subcontracting at Consolidated during World War II quite conclusively proved that the facility of the prime contractor alone would not have been adequate to have accomplished the requirements of the war. Looking backward at the overall subcontracting program, the following is an appraisal of the plan and the effectiveness of its operation.

The control of a subcontractor was accomplished by showing a cooperative spirit, a free exchange of ideas and practices, and proper coordination of all problems. Managerial control of the subcontractor did rest, and of necessity must always rest, with its own management unless the subcontractor is to be wholly subsidized.

Subcontractors cooperated well with respect to rate of production, improvement in quality, and curtailment of operating inventories. Contrary to some other experiences, this contractor's subcontractors did not proselyte home plant labor.

Clock-like precision in many cases was obtained on shipment of parts from the subcontractor and receipt and usage by the prime.

In regard to transportation, rail facilities were used whenever possible and where time permitted. Trucking facilities, however, allowed better control, less difficulties in handling, and more flexibility in its operation. In some instances it was necessary to resort to alternative methods of transportation due to breakdowns, weather, and other localized situations. Rail express and air express were used to a heavier degree because of the time element. Cost of transportation was always secondary to the importance of delivery and production requirements. Interruption of the final assembly line was not tolerated. Expediting the movement of parts was fully as important as expediting the manufacture of the part.

Inspection procedures of the subcontractors were improved by liaison inspectors of the prime contractor, although every effort was made to establish the subcontractor's inspection as an independent and responsible unit. It was demonstrated that improvement of the subcontractor's inspection department and procedures was a much better approach to the quality control problem than to establish customer inspection at the source. Educating the subcontractor in the proper methods of handling and manufacturing aircraft units did much to relieve inspection's troubles. Necessity for rework by the prime contractor was established through his Inspection Department and coordinated through the Negotiation Section of the Subcontract Department. Charges for necessary rework were billed back to the subcontractor after coordination as to determination of responsibility and prevention of recurrence of the rejection through eliminating its cause.

Subcontractor's objections to the incorporation of engineering changes many times caused considerable difficulty. However, with the growing realization that such changes were for improvement of the product or were made for military necessity, they became more cooperative. It is only natural that such changes which upset a production program or even caused a stoppage of work would be received with reluctance.

The plan to subcontract as a specialized function was well timed, and the usual problems attendant to a growth of such magnitude had their many complications. Too few industries had experience with the type of manufacture required, the type of materials involved, such as aluminum alloys and plastics, and the techniques and dimensional tolerances which were more or less foreign to their usual work. The design of the parts and the available engineering was in most cases less complete than that to which they were accustomed. The processing of the material and the weight saving factors so necessary in aircraft design were new problems.

FEEDER SHOPS

When manpower became critical at San Diego, Consolidated endeavored to help relieve the condition by setting up feeder shops in areas remote from the main plants, thus utilizing labor which could not be induced to come to San Diego.

The Feeder Shop plan developed by the Contractor was actually a supplement to subcontracting. The large number of items which were sent to the feeder plants might have been subcontracted easily as they were simple complete units but they were not attractive contract items in the volume available between changes because they were also relatively small in size, weight, and manhour cost. The principal items were plastics, electric and hydraulic systems, and upholstery. All building leases and alterations of feeder shops were arranged by Consolidated; all personnel employed were on the company payroll and full control of these shops was vested in the San Diego Division. In fact, these feeder shops represented removed sections or departments of the main plant at San Diego.

Attention is called to the exhibit entitled "Feeder Shop Data" in which is given a list of the shops, their locations, the type of work done, floor space and other pertinent information. At peak operation the feeder shops accounted for approximately 10% of the total manhours expended on the plane. It is interesting to note that the first feeder shop was put into operation just one year after Pearl Harbor.

Locations:

The locations of the feeder shops are shown on the accompanying map. By pioneering the feeder shop idea, Consolidated was able to obtain the most desirable and least expensive locations available. The various Chambers of Commerce, municipal officials, and the Southern California Edison Company were extremely helpful and cooperative in the search for manufacturing sites.

Alterations:

Practically all of the alteration work was done by local contractors on a cost-plus-fixed-fee basis. Many shops were completely altered in a matter of a few days in spite of manpower shortages and difficulty in obtaining materials.

Alteration costs were capitalized to be written off during the term of the leases. Some heating equipment and all the air compressors were owned by the Defense Plant Corporation.

Alteration materials were obtained under a blanket priority list, approved by the W.P.B., and requested in advance for a series of

Subcontractor	Location	Item
General Fireproofing Co.	Los Angeles, Calif.	Track Assembly
Gilfillan Bros., Inc.	" " "	Arm Drive Mech.
" " "	" " "	Yoke Nose Drive Mech.
" " "	" " "	Gear Eng. Drive Mech.
Goodyear Tire & Rubber	" " "	Oil Cells
Grand Rapids Store Equip.	" " "	Side Gunners Door
" " "	" " "	Control Guards
" " "	" " "	Life Raft Cradle
Hook Rubber Co.	Watertown, Mass.	Rudder Tabs
" " "	" "	Aileron Tabs
Kawneer Co.	Berkeley, Calif.	Bomb Racks
Kaydon Eng. Corp.	Muskegon, Mich.	Wing Splice Fitting
La Porte Corp.	La Porte, Ind.	Pin Assembly
Langley Corp.	San Diego, Calif.	Tab Control
" "	" " "	Control Column
" "	" " "	M.L.G. Release
" "	" " "	Gear Box Assemblies
Leonard Precision Prods.	Garden Grove, Calif.	Pump Screen Assemblies
" " "	" " "	Machining Work
Mahl Mfg. Co.	Huntington Park,"	Longerons
" "	" " "	Hanger Assembly
Monarch Tool&Inst. Co.	Los Angeles, Calif.	M.L.G. Bumper
Motor Products Corp.	Detroit, Mich.	Tail Turret
" " "	" "	Ammunition Tracks
Na-Mac Products Corp.	Hollywood, Calif.	Scavenging Kits
Nat'l Machine Products	Los Angeles, Calif.	Control Column
" " "	" " "	Sprocket Assembly
" " "	" " "	Machined Parts
Nat'l Supply Co.	Torrance, Calif.	Main Landing Gear
Pryne & Co.	Los Angeles, Calif.	Hydraulic Tank
Rheem Mfg. Co.	Los Angeles, Calif.	Nose Bottom Panels
Rocky Mt. Steel Products	" " "	Flap Indicator
Rohr Aire. Corp.	Chula Vista, Calif.	Power Plants
" " "	" " "	Quick Change Engine Parts
" " "	" " "	Rear Nacelle
Ryan Aero. Co.	San Diego, Calif.	Aileron Assembly
" " "	" " "	Elevator Assembly
" " "	" " "	Outer Wing Panel
" " "	" " "	Rudder
San Diego Mach. Co.	" " "	Handle Assembly
" " " "	" " "	Bellcrank Control Assembly
" " " "	" " "	Machining Work
Schiefer & Sons	" " "	Amplifier Cover
" "	" " "	Door Panel
" "	" " "	Fuselage Floors

Subcontractor	Location	Item
Schiefer & Sons	San Diego, Calif.	Map Cases
" "	" " "	Cargo Carriers
Shakespeare Prods.Co.	Kalamazoo, Mich.	Throttle Quadrants
Southern Aire. Corp.	Garland, Texas	Tail Turret
Southern Calif.Airparts	Glendale, Calif.	Hydraulic Tank Assembly
Solar Aircraft Co.	San Diego, Calif.	Exhaust Collector
" " "	" " "	Stack Assembly
Spartan Aire. Co.	Tulsa, Okla.	Aileron Assembly
" " "	" "	Elevator Assembly
" " "	" "	Rudder
Super Cold Corp.	Los Angeles, Calif.	Bomb Racks
" " "	" " "	Pilot Seat Floors
" " "	" " "	Tail Bumper
Superior Machine Co.	San Diego, Calif.	Machined Forgings
Techlite, Inc.	Dallas, Texas	Trailing Edge Overflap
Timmarsh Eng. Co.	Tucson, Ariz.	Aileron Tabs
Timm Aire. Corp.	Van Nuys, Calif.	Hyd. Res. Assembly
Vendo Co.	Kansas City, Mo.	Tail Turret Guide
Vultee Fld.Div.,CV4C	Downey, Calif.	Wing Tips
" " " "	" "	Fins
Weaver Aire. Corp.	San Diego, Calif.	Machining Work
Welded Aire. Parts Co.	Huntington Park,Cal.	Bomb Supports
" " " "	" " "	Spare Bomb Chocks
" " " "	" " "	Flap Track Supports
Westn.Industrial Eng.Co.	Los Angeles, Calif.	Pilots Enclosure

During the early part of 1944, subcontracting reached its peak with respect to quality, volume, manhour efficiency and cost. At this time the subcontracted 40% of total manhours representing 37% of total weight was reduced by subcontractor efficiency to 33% of total manhours at 30% of the dollar value of the airplane.

During the month of May 1944, at peak production, 2,715,650 pounds of airframe weight (120 equivalent airplanes) were received from subcontractors, representing 1,921,662 manhours at a cost of $6.28 per manhour, or $4.45 per pound. This was equivalent to 0.71 pounds per manhour.

No reversals in the original plan were made at any time but the deviations effected were the result of experience and aggressive initiative and were a growth toward improvement in coordination and methods to accomplish the utmost efficiency.

Learning Curve Data:

When a job was first given to any subcontractor, realistic scheduling was accomplished not only considering the plant's facilities but by determining the necessary manpower required for the job. This was based on standards or experience in the prime contractor's plant.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division * * San Diego, Calif.

LEARNING CURVE SCALE

The learning curve scale was conceived by the Subcontracting Department, San Diego Division of the Consolidated Vultee Aircraft Corporation. This scale is designed to draw learning curves on logarithmic graph paper. On ordinary arithmetic graph paper the learning curve is like half a parabola with a formula $Y = K X^n$. On logarithmic graph paper, which is measured in horizontal and vertical logarithmic scales, the learning curve becomes a straight line.

The learning curve scale is designed for a general construction of learning curves with 5% variations from a 70% to a 95% learning curve. It can be used for two general purposes. The first purpose of the scale is to construct a learning curve in anticipation of expected performance in the production of a specific assembly. Typical assemblies would be elevators, fins, outer wing panels, or smaller assemblies. Each assembly must be a completed unit as required for each airplane, and the performance must be measured in terms of direct labor man-hours per ship set only.

In order to anticipate an expected performance, the nature of the assembly must be analysed as to the percent of fabrication man-hours and the percent of assembly man-hours required to produce the complete assembly. This information may be obtained from a time study breakdown, or estimated. An extensive study of aircraft production has established the 80% learning curve to be the most typical curve for predicting expected production performance. Therefore an 80% learning curve is anticipated in all cases except those where the percent of fabrication man-hours of the total man-hours required to build the unit is very low or very high. A very low percent of fabrication time would indicate an expected performance along a 75% or even a 70% learning curve. Conversely, a very high percent of fabrication time would indicate an 85% or even a 90% learning curve.

The learning curve scale is employed to construct both the cumulative average learning curve and the unit man-hour learning curve. (Refer to Chart A appended.) The cumulative average learning curve expresses the average man-hours per ship set for a cumulative total of ship sets that begin with the first ship set, and it is drawn with a solid line. The unit man-hour learning curve expresses man-hours per ship set for each ship set, and it is drawn with a broken line.

Company A estimated that it would build the 500th ship set of assembly #32 in 450 man-hours along an estimated 80% learning curve. Referring to the table of conversion factors inscribed on the learning curve scale, the conversion factor for an 80% curve is .678. Dividing 450 man-hours for the 500th ship set by this factor gives an estimated

664 cumulative average man-hours per ship set (mh/ss) for the first 500 ship sets. Using the learning curve scale 80% learning curves are drawn through these two values with a red colored pencil to anticipate Company A's expected production performance.

From a time study breakdown it is learned that Assembly #32 had a standard time estimate of 338 man-hours at about the 1,000th ship set at the San Diego Division of Consolidated Vultee Aircraft Corporation. Dividing 338 man-hours for the 1,000th ship set by the conversion factor of .678 for an 80% curve gives a cumulative average of 499 man-hours per ship set (mh/ss) for the first 1,000 ship sets. Using the learning curve scale 80% learning curves are drawn through these two values with a blue colored pencil to represent the San Diego Division's performance in producing Assembly #32. A favorable comparison is observed between Company A's estimate and the CVAC Standard Time learning curves.

The cumulative average learning curve and the unit man-hour learning curve are parallel lines, and they are both drawn with the same scale. For the first two ship sets, however, the unit man-hour curve is only an approximation and must be drawn upward to meet the cumulative average curve at the first ship set. For any given ship set multiply the cumulative average mh/ss times the conversion factor for the percent learning curve being used to arrive at a value of the time to build that particular ship set; or divide the time for a given ship set by the conversion factor to arrive at the average mh/ss for that cumulative number of ship sets.

The second use of the learning curve scale is to determine the actual production efficiency after the job has progressed a few months. A company whose actual production performance maintains an 80% learning curve is reducing the man-hours per ship set by 20% when the total number of ship sets is doubled. Hence a 20% production efficiency is established for that company, or an 80% learning curve. By plotting the company's actual performance on the learning curve chart using horizontal lines for each lot size the actual production efficiency, or the actual learning curve the company is maintaining, can be measured by a reading from the learning curve scale. Merely place the scale over the chart, and by visual inspection determine which percent of learning curve most nearly lines up the middle ship set of each month's performance indicated by horizontal lines. On Chart A the actual performance is drawn with a green line for three months. Lining up the middle ship set of each month and reading through the learning curve scale indicates that Company A is actually maintaining a 75% learning curve over the first three months. During the first month, however, Company A may have had unusually high costs in starting production. Therefore, by considering the last two months to be more typical performance, the learning curve scale is applied to these

two months to show that Company A is maintaining an 80% learning curve as originally anticipated. (This sample chart was taken from an actual case in the files of the Subcontracting Department). In this particular case it is observed that Company A's actual performance is more nearly represented by the blue broken line of the CVAC Standard Time curve than by Company A's originally estimated learning curve, the red broken line. Therefore, it would be conservative to say that Company A will maintain production performance along their estimated 80% learning curve that is drawn with a red broken line. Future performance may be anticipated along this curve for determining future production costs in terms of man-hours. Projected Labor Loads based upon this chart and the production schedule will tend to show the number of workers required to meet the production schedule. Several other important facts may be learned from a learning curve chart similar to chart A. Further information may be obtained upon request.

Man-hour reports must be submitted by Company A in order that the actual performance may be plotted on Chart A. These reports must be submitted periodically -- weekly, twice a month, or monthly, depending upon the company's methods of timekeeping. The weekly reports are most desirable, however, and are requested wherever possible. A man-hour report must show three things: (1) the total number of man hours expended on the quantity of assemblies produced during a defined period of time; (2) the average number of man-hours per ship set allocated to the construction of each completed assembly during this period; and (3) the number of assemblies completed during this period.

A company that builds an assembly in lot sizes of 100 ship sets, for example, may submit a man-hour report upon the completion of each lot. All of the direct labor man-hours expended on each lot may be charged to that lot, and an actual count of man-hours per ship set may be computed when the lot is completed. The size of the lot and the date of completion must also be reported.

Most companies, however, report on a weekly basis. The number of completed ship sets is actually counted as they are completed and shipped. The total number of man-hours expended on each job is recorded by timekeepers and included on the man-hour report. The figure for man-hours per ship set should be computed. This may be determined by periodic time studies in the shop, or it may be closely estimated according to the total man-hours expended, the ship sets completed, and the amount of man-hours in process. The number of man hours in process for the next period of units to be completed can be computed by using a time study breakdown to determine the percentage of hours for fabrication of details. For example, this fabrication time would be 25% of the hours for a completed unit. Therefore, subtract from the total hours spent 25% of the hours

and hold this figure to be added to the following period. Do this for each lot of parts. Weekly man-hour reports are summed up for monthly averages as in the case of Company A. (Refer to Table A appended.) By the end of November Company A had completed 95 ship sets. The cumulative man-hours allocated to the job totaled 104,950 man-hours. The cumulative man-hours actually expended on the job exceeded the allocated man-hours by nearly 40,000 man-hours at the end of November. These 40,000 man-hours are recorded on another form as a man-hour backlog representing work yet in process. The allocated man-hours are computed by multiplying the number of sets completed times the man-hours per ship set. The man hours per ship set may vary up or down considerably from week to week, but by totaling the allocated man-hours and the ship sets for each month, an average man-hours per ship set for the month may be determined. In this way the estimated value of "man-hours per ship set" will be averaged out, and the fluctuation will be reflected in the man-hour backlog.

While a company is accelerating its production schedule the man-hour backlog will be increasing due to the greatly increasing number of man hours going into processing while the number of completed ship sets is yet small. Such allowances must be made in determining "man-hours per ship set". After four or five months of production, or when the schedule levels off to a constant rate, the man-hour backlog should remain fairly constant. Thus if 100 ship sets are fabricated each week and the same number of ship sets are completed each week, the man-hours going into processing and coming out of processing are practically equal. Only then may it be estimated that the actual man-hours expended equals the allocated man-hours, so that the actual man-hours expended divided by the number of ship sets completed will give "man-hours per ship set".

In any event the allocation of man-hours per ship set will be averaged out over a period of several reports, and a running account will be made as to the remaining man-hours of backlog that are yet in process. It is only by means of complete man-hour reports that a company's actual performance may be plotted on the learning curve chart. Only when this actual performance has been plotted can the learning curve scale be used to measure a company's actual production efficiency and learning curve. Estimates can then be made of future production costs in terms of man hours.

January 1, 1944

Howard G. Coleman

feeder shops." It is believed that this was the first "blanket" priority assistance used for construction materials.

Employment:

No difficulty was encountered in any of the locations in obtaining employees. Male workers were scarce, but the women were above average and had a marked enthusiasm to help in the war effort.

Most of the new hires were referred to Consolidated's Employment Department by the U.S.E.S. bureau office in the area, and all new hires were cleared through this office for availability. Each feeder shop was given priority for labor up to the shop's estimated maximum capacity.

In addition to the above, Consolidated's Employment Department established its own Feeder Shop hiring headquarters at Santa Ana, this point being centrally located with respect to the majority of the feeder shops.

Supervision:

All of the general foremen and some of the foremen and assistant foremen were transferred to the feeder shops from San Diego. Fourteen assistant foremen, however, were developed from men hired locally, and in fact most of the assistant supervisors were developed from local sources.

Tooling:

A representative of the Tooling Department in San Diego, responsible to this Department, spent full time at the feeder shops. This representative was responsible for making repairs and minor alterations to subassembly production tooling. Major changes and repairs were all made in San Diego.

Production Control:

Each feeder shop had Production Control personnel under a Head Dispatcher who reported to the Superintendent of Feeder Shops. At five of the shops, the Head Dispatcher was hired locally as a stock clerk and promoted to assistant foreman in Production Control. The balance of assistant foremen in this category were transferred from the Production Department in San Diego.

Material:

A material warehouse (43,000 sq. ft.) was established in centrally located Santa Ana to store all raw stock, plexiglas, tubing, fabric, wire,

commercial material and stores items, janitor supplies, etc.

Inspection:

The Head Inspector at most feeder shops was transferred from the San Diego Inspection Department and was responsible to that Department. All assistant inspection personnel were developed from local hires.

Transportation:

Materials, details and finished parts were transported between San Diego and the feeder shops by Sorkness Truck Lines under contract. A Sorkness truck delivered and picked up material at each shop once a day. For more details on trucking, tonnage and costs, refer to the accompanying Feeder Shop Tonnage Report.

Time Studies:

Direct labor time studies were established at most of the shops, and the assistant supervisors participated in a cost conversion bonus based on their shops monthly production. Arbitrary standards were established at shops where time studies had not been completed.

Comparison of a few individual operations such as tube bending, indicated a high degree of efficiency on the part of feeder shop workers.

First Aid:

All feeder shops had a complete First Aid Station either at the shop or within a short distance. Registered nurses were in attendance full time except in a few cases where the small number of employees justified only one nurse working a split shift.

Plant Protection:

All feeder shops had plant guards for at least two shifts.

One shop had an entire sprinkler system, and in the others a 1½" fire hose installation was made to extend within 20 feet of any part of the shop. Fire extinguishers were installed in accordance with regulations. All first floor windows were screened.

The above requirements satisfied recommendations made by the Army for plant protection.

Coordination:

All feeder shop requirements from San Diego and vice versa, were handled through a Chief Coordinator's office located at Plant #2, San Diego. All matters pertaining to materials, completed parts, details, equipment, tools, etc., cleared through this office.

STATISTICS ON AN AVERAGE FEEDER SHOP *

LOCATION

Distance from San Diego	101 Miles	
Floor Area (Square Feet)	Direct 11,501 Indirect 3,030	Total 14,531
Building Alterations	$ 7,371.12	$.51 per sq. ft.
Heat & Air Compressor Installation	2,635.67	.18 " " "
Total Alterations and Additions	10,006.79	.69 " " "
Monthly Rental	$ 244.28	.016 " " "

PERSONNEL

Total Employees	Male 50 Female 160	Total 210
Percentage Female Employees	.....	76%
Percentage Direct Employees	.....	79%
Percentage Female Direct to Total Direct	.....	79%
ABSENTEEISM (Nov. '43) Ration of Direct Manhours Lost to Manhours Scheduled	.....	6.5%
TURNOVER (Nov. '43) Hires Per Month Per 100 Employees	.....	14
Terminations Per Month Per 100 Employees	.....	9

PRODUCTION

Direct Manhours Per Pound	.....	.49
Total Manhours Per Pound	.....	.60
Pounds Per Square Foot Direct Area (Dec.'43)	.....	6.36
Direct Manhours Per Square Foot Direct Area (Dec.'43)	.....	3.10
Square Foot Direct Area Per Direct Worker (First Shift Only)	.....	127

TRANSPORTATION

Trucking Charge Per Month	$1,154.50	$.01 per pound

* Average taken from seven Feeder Shops operating nearest to capacity.

MONTHLY FOUNDRY SHOP TONNAGE REPORT

DECEMBER, 1943

F.Shop Depts.	Outbound Weight*	Outbound Cost	Inbound Weight*	Inbound Cost	Total Weight*	Total Cost	Tax	Spec. Trips	Min.Chg. Contract	Aver.Cost Per Pound
901	36,195	$ 317.77	65,955	$ 614.53	102,150	$ 932.40				
902	46,450	310.16	100,175	785.83	146,625	1,095.99				
903	52,785	465.52	62,880	559.96	115,665	1,025.48				
905	40,165	358.70	77,685	687.94	117,850	1,046.64				
906	12,085	98.81			12,085	98.81				
910	9,290	89.25	38,590	362.82	47,880	452.07				
915	80,119	723.88	60,428	666.58	140,547	1,390.46				
925	159,320	1,034.89	172,720	1,103.62	332,040	2,138.51				
930	47,625	509.53	34,885	376.54	82,510	886.07				
935	49,891	480.31	42,521	422.10	92,412	902.41				
940	34,152	342.26	16,002	177.42	50,154	519.68				
947	69,605	520.33	66,310	465.88	135,915	986.21				
Total	637,682#	$5,251.41	738,151#	$6,223.32	1,375,833#	$11,474.73	$356.64	3	$1,975.00	$0.01003
					Grand Total Cost ...	$13,806.37				

* Includes tare weight of about 12% which was deleted for production figures on a previous page.

FEEDER SHOP DATA *

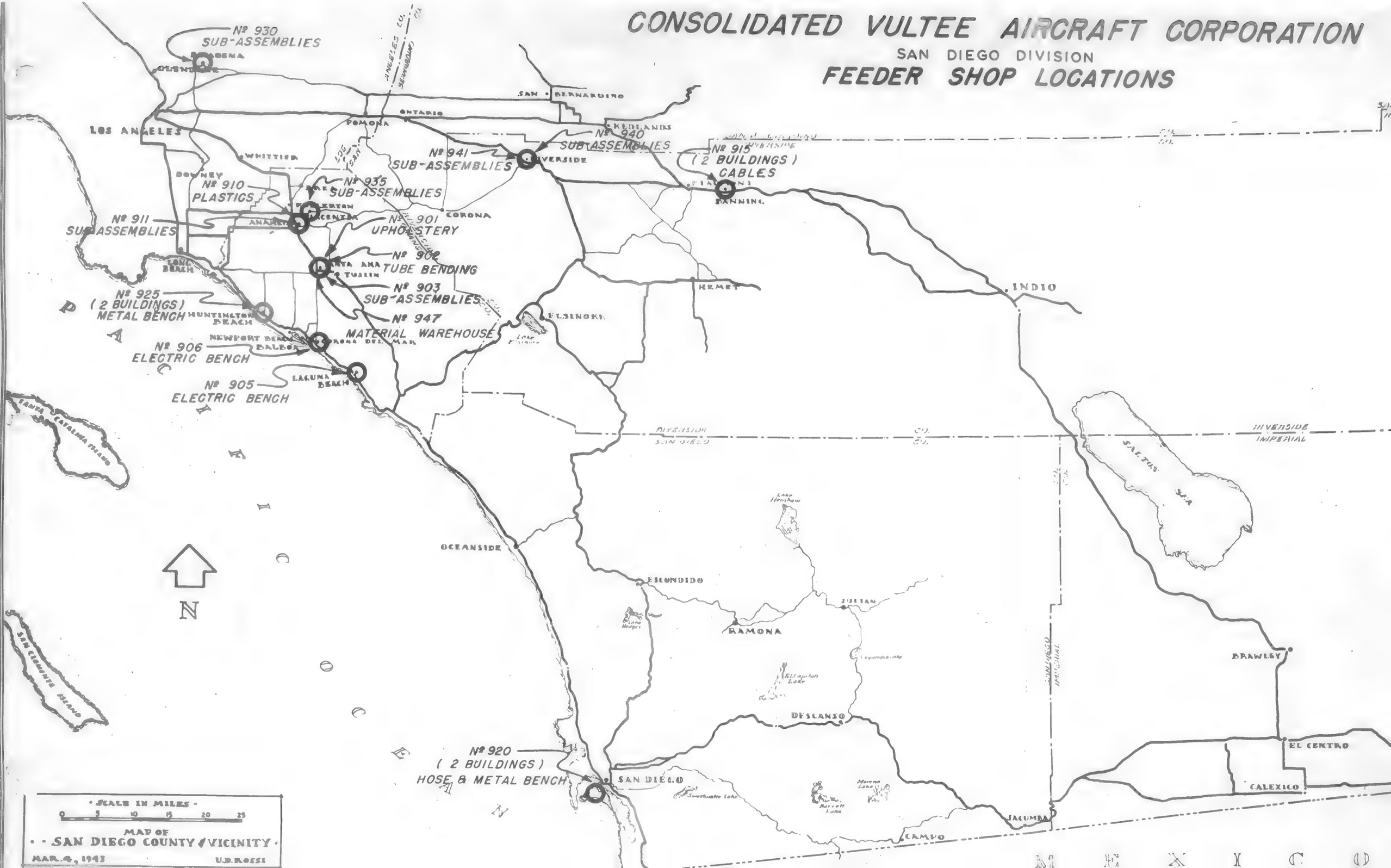
Dept. No.	Location	Dist.fr. Main Plt.	Floor Space	Products	Day	Personnel Night	TO [illegible]
901	Santa Ana	91	7,656	Covering & Upholstering	83		
902	Santa Ana	91	23,324	Tube Bending	124		
903	Santa Ana	91	19,139	Sub-Assembly	111		
905	Laguna Bch.	72	19,600	Electric Bench	184		
906	Corona Del Mar	81	7,508	Electric Bench	61		
910	Anaheim	101	9,283	Plastics	60		
911	Anaheim	101	12,171	Sub-Assembly			
915	Banning	166	10,162	Cables	63		
920	Coronado	5	3,349	Bench & Salvage			
925	Huntington Bch.	93	16,961	Metal Bench	149		
930	Pasadena	135	11,135	Sub-Assembly	90		
935	Placentia	103	6,592	Sub-Assembly	54		
940	Riverside	134	8,779	Sub-Assembly	67		
	TOTALS		155,657				

* Information as of 1 February 1944.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION

SAN DIEGO DIVISION

FEEDER SHOP LOCATIONS



· SCALE IN MILES ·

0 5 10 15 20 25

MAP OF

· · SAN DIEGO COUNTY & VICINITY ·

MAR. 4, 1943 U.D. ROSSI

INSPECTION

The inspection policies of the contractor were at all times commensurate with the quality to be expected in aircraft production. The execution of these policies was hampered at times by lack of trained inspection personnel (both company and Army), and by failure of the services to coordinate their inspection directives. In spite of these handicaps the company was able to give practically 100% inspection on the site and maintain the required standards without seriously retarding the flow of production materials to the line.

Operation:

The organization of the Inspection Department consisted of a Division Chief Inspector reporting directly to the Division Manager with chief inspectors in all plants of this Division, namely Plants #1 and #2 and the Tucson Modification Center. To assist these chief inspectors, general supervisory inspectors were placed in all sections, such as Receiving, Fabrication, Shipping, etc., with such assistants as needed to give the required inspection. Copy of organization chart of the Inspection Department is attached for reference.

The ratio of inspectors (who served the direct workers) to the direct workers varied with the different sections of the Shop Production Departments. However, the overall ratio ran from 1:9 to 1:15. It was found that during the rapid expansion program and the period immediately following, an overall ratio of 1:12 was necessary to give the desired inspection control and maintain the high quality of the product.

Personnel:

The hiring of sufficient qualified personnel was one of the company's greatest problems during the time of rapid expansion. Although most of these employees were obtained through the normal employment channels, some of the better grade and specialists were obtained by personal contact and recommendation. Many were also selected from the Aircraft Trade schools by sending company management to these schools throughout the country. Later in the production program an extensive schooling program was undertaken by the Educational Department and in addition to the normal schooling of newly hired personnel a course was given in General Inspection Knowledge and Procedures, Blueprint Reading, Electrical Radio, Artificial Ageing and Heat Treat, Materials Review and Salvage, Engineering Procedures including Blueprint Numbering and Part Numbering, Aircraft engines, Sperry Turrets, Propellers, and Rivets and Rivet Control.

Recommendations:

It is thought that the present system of AAF inspection, if revised would result in considerable improvement relative to expediting production and yet would not sacrifice the desired quality control. Such revisions would include -

1. That all sources of raw material and purchased parts have a basic quality control by the AAF for the materials (correct alloy composition and temper) and fabrication processes. This method would lift the burden from the aircraft manufacturer and assure him that all materials, parts and assemblies received from certain vendors (certified by the AAF) would require him to do no checking except for damage en route.

2. That only a limited number, but well qualified, inspection personnel be permanently assigned to the manufacturer and that their function be entirely supervisory in nature. Army inspectors should check only the company system of inspection, and in a general way the finished airplane on the flight line, leaving with the company complete responsibility for all detailed quality control.

3. Technical Directives and information received from combat units should be filtered through one section of the AAF so that all directives would be issued from one source and by qualified personnel who understand and are acquainted with all phases of aircraft manufacture.

The suggested revisions of the AAF inspection system outlined above, would require only a very limited number of men, but it would be very essential and necessary that this limited number of men be fully qualified in their work with a background of experience. These revisions would, in addition, expedite production and reduce unnecessary production hold-ups and differences of opinion.

SPARE PARTS

Summary:

Considering the total B-24 program and based on its dollar value, spare parts were shipped in an amount equal to 16.4%, with 1% being shipped on emergency TWX orders and 2.4% on stock replenishment calls. The organization to handle this load grew from nothing to a total at peak of 327 persons while passing through several stages of evolution to work out the most efficient system. Concurrency was not reached on any of the contracts by the date of peak production, indicating clearly that the AAF spares program was not crystallized early enough to prevent its becoming a definite load on production acceleration.

The Plan:

"The Spares Department was at first not given very much recognition as to its importance in the general picture." Space, personnel and real planning were always scarce. The original plan called for a group to do its own work, planning, scheduling, dispatching, ordering and storekeeping in producing contract requirements of spare parts.

Experience in Operation:

As the problems of control grew it became necessary to split this group and carry the load in the several sections of the production and material control sections assigned to handle all production requirements of similar items. The Spares Group as finally constituted concentrated on the final allocation of the spares items and their preparation for shipment. Space was finally granted in total of 55,000 sq. ft. in a separate building directly over the shipping department where the packaging and shipping operations were performed. Of this total space 80% was used on the B-24 program.

The major problems were definition of requirements, supply, that is the available total quantity of critical items, priority relative to the production program, and packaging. Failure to solve these problems lead first to the "post-concurrency" record and second to the recommendations set forth below. The Spares Program started out on each contract with a serious handicap - the Army did not fix the list of items and quantities at the time of contracting nor for some time afterward. This made planning difficult and concurrency impossible. The necessary changes in the list, as time passed, further complicated control, but in spite of handicaps results were more than reasonably satisfactory as evidenced by the small volume of emergency shipments - one per cent according to the record.

As shown in the following table, spares concurrency crawled upward slowly during the acceleration period to the 80% level at peak. As the requirement for airplanes fell off, the spares program became relatively less of a load and it rapidly reached a practical 100% figure.

Percentage Concurrency - Quarterly:

	Overall Average
1 January 1943	24.50
1 April 1943	25.
1 July 1943	26.50
1 October 1943	64.67
1 January 1944	79.25
1 April 1944	80.20

Recommendations:

Spares requirements must be fixed by the Army at the time airplane production requirements are fixed. It is not essential that the list of items or quantities be complete or correct, but a release for production of a major portion of the final list must be made not later than time of first general shop releases if concurrency, to say nothing of pre-concurrency, is required.

The volume of spare parts manufacture should be carried on in an entirely separate and completely staffed and equipped plant. Certain items requiring expensive equipment should be excepted from the rigid application of this policy, and "purchased" from the main plant. In the case of multi-plant operations for airplanes in large volume demand, one plant should be given the contract for all of the spares.

The specialized depot should be operated under contract by the parts manufacturer and adjacent to the plant. This simplifies the control problem as well as those of stockage and packaging, and fixes the responsibility for supply.

Careful consideration should be given to the contractor's earlier recommendation (see letter of 7 January 1943, copy in Appendix) that operating bases should draw direct on this depot making requisition and pick-up by air transport. It appears that this proposal would definitely decrease the number and time of airplanes grounded for parts and very greatly decrease the total requirements for spare parts.

CONSOLIDATED AIRCRAFT CORPORATION
San Diego, California

COPY/hmc
10-18-45

FW:hmc:ff
A. Misc.#3953

7 January 1943

Subject: B-24D Airplanes,
"Cadaver" Plan for Supplying Spares

To: Commanding General
AAF Materiel Center
Wright Field
Dayton, Ohio

Attention: General K. B. Wolfe
Chief, Production Division

Via: AAF Resident Representative
San Diego Area

Reference: (a) AAF Mat. Con. Letter DM:new:70-7
dated 1 December 1942

1. Concurrently with the receipt of the referenced letter, there was received by us as an appendix to the most recent production contract for B-24 airplanes a program entitled "Army Air Forces Spare (Maintenance) Parts Provisioning" setting forth a complete system for echelon packing of spares and the creation and maintenance of contract spare parts lists. It is felt that there is certain fundamental conflict between this program and the so-called "Cadaver" plan for supplying spares. This plan also provides for a flight kit of spare parts to accompany each airplane.

2. The Contractor recognizes the appropriateness of holding open all angles of approach to the spares problem and of initiating, cancelling and reconsidering various programs in this regard. It is obvious that changing war theaters and varying applications of the B-24 type aircraft to combat conditions necessitate flexibility and even abandonment of former established policies as regards spares. Our observations, as gathered from our several service representatives abroad, suggest that not only are earlier peacetime procedures developed in this country for the production, delivery and distribution of spare parts inappropriate under current conditions but that even those procedures which have grown out of experience in England may offer little assistance in the handling of the American problem outside of the British Isles.

To: AAF Materiel Center
Attention: General K. B. Wolfe - 2 -

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3. To state the matter in another way, the problem of spare parts provisioning in the actual theaters of combat does not resolve itself purely into one of the most economic uses of available man hours. Man hours at point of combat and man hours in terms of shipping space may well carry an extremely high premium in comparison with man hours at the factory. Thus as suggested in the "Cadaver" plan, the abandonment of a complete airplane at the theater of operations after it has served the limited purpose of supplying critical spares to an operating squadron, may be an efficient use of the man hours at the factory which it took to assemble the parts making up the airplane into a flying unit.

4. We would from our study of the problem, however, suggest a variation in the "Cadaver" plan. We are impressed from the reports of our own representatives abroad with the fact that a "Cadaver" airplant would supply but a limited amount of the very critical items of spares required by an operating squadron. It would furnish four engines, one left and one right outer wing panel, one tail assembly, one complete landing gear, etc. This might well be an over-supply of certain items but would prove to be a serious under-supply of others. Consideration has been given to the additional spares which could be carried aboard such an airplane to the point of combat. However, even with these the "Cadaver" plan would not appear to be a completely adequate substitute for the tremendous spare parts program now in operation.

5. On the other hand, this larger spare parts program has as many doubtful aspects as far as efficiency is concerned. The only spares to be counted from the standpoint of the war effort are those which actually arrive at the point of ultimate use. All of those spare parts in storage in bases in the United States, in transit to foreign theaters, at central distribution points and enroute to actual point of combat have no direct utility in meeting the problem. They are equivalent to the water in the hose in a garden irrigation process. The larger the hose and the smaller the stream, the more water which never serves to feed the plants.

6. The fundamental premise of all spares supply is to have the right part at the right place at the right time. To be able to supply this right part from any given point calls for a range of parts at that point. Out of such a range, certain parts will be called for more frequently than others. The total supply of parts at the given point must therefore be multiplied in certain items by a frequency factor which is a function of the number of days' time which must elapse to cover shipment from point of origin or production of the spares.

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7. Thus, if a base in India is 67 days from dockside New York which is 10 days from the factory, the minimum stock of spares to be tied up at the India base is one full range plus a 77 day factor of all parts in the range having average demand of more than once in 77 days. Since the demands of war are not closely calculable as to parts needs, this quantity of parts in storage in India must more probably take into account maximum possible demand of each item. This further increases necessary stocks. Add to this again the ability to rapidly shift squadrons of long range aircraft, and an additional multiplication of all parts must be made to meet the contingency of a concentration to be cared for out of the particular base.

8. Take this one base and multiply it by the number needed to cover the world under an orthodox peacetime distribution of depots and sub-depots and it becomes immediately obvious that such a program cannot work. Add again the additional fact that even concurrent delivery of spares and airplanes at the factory must create a lag of as much as three months in the two joining each other again abroad, and it becomes foolish to even attempt the operation of such a system.

9. The obvious answer hardly needs to be stated. First, we must cut the number of days from source of parts to point of final use. This will shrink the frequency factor and decrease the quantity of parts in float in the system. Second, we must cut the number of points of supply to decrease the quantity of full ranges of spares required.

10. All of this points to -- specialized air transport -- to handle this problem alone. One form of such specialized air transport is the "Cadaver" plan under which the spares would be moved direct from the factory to the operating squadron both in the form of cargo in an airplane and in the form of the parts which make up the airplane itself. While this gets a full range of spares to the point of need in the absolute minimum of time under any conservative plan, it does not permit more than a limited frequency factor on particular items which can be carried aboard the airplane. It is felt that the "Cadaver" airplane can furnish a greater use by returning immediately to the source of spares, the factory, with a list of critical items with which to replenish the operating squadron's stock. Under such a plan, let us assume that 20 B-24 airplanes are to be assigned as a squadron to operations in North Africa. Nineteen of these airplanes depart the United States operationally complete for the required missions. As such but without bomb load, each is able to carry to its base approximately a thousand pounds of the most critical spares. These will probably consist of essential handling equipment such as wing jacks, etc., plus hydraulics, electrical, radio and engine accessories which experience has proven

are critical items. The twentieth airplane is converted to a cargo carrier and is capable of departing with its squadron with an additional 7000 pounds of spares of the same type. In all, therefore, 26,000 pounds of spares arrive at the base of operations with the squadron.

11. Immediately on arrival, the converted cargo carrier starts back for an additional load of spares bringing with it such a list of urgent items as the original ferry trip has revealed necessary. In eight days this airplane should be back with an additional 7000 pounds of spares consisting of items of an immediately known need plus such additional items as are felt necessary to add to the original stocks. This process is repeated with each trip caring for aircraft on the ground and building up the squadron's quota of additional spares. During all of this time the squadron has been able to carry on operations and has received a minimum of spares which it will not need.

12. It is felt that it can be proven that the total quantity of spare parts saved by this air transport process as against the orthodox method of spares distribution could be made up into airplanes without reducing the quantity of operational bombers and still leave a far more extensive supply of spares actually available for use.

13. For an example, let us start with 1000 B-24 type airplanes -- two months' production. Spares for these will equal 250 equivalent airplanes at a 25% ratio. Under the surface transport and depot system these might be distributed approximately as follows:

10	Depots and Sub-Depots in the United States
1	Alaska
1	Hawaii
3	Australia
2	China
4	India
3	Egypt, Palestine and Middle East
2	England
1	West Coast of Africa
1	South America
28	TOTAL

14. This calls for a movement of 10,000,000 pounds of cargo over distances as far as three-quarters of the way around the world. It also means delays of as much as three months and possibly a 10% loss from shipping.

To: AAF Materiel Center FW:hmc:ff
Attention: General K. B. Wolfe - 5 - 7 January 1943

15. Now take 100 of these equivalent airplanes in spare parts and have them made up at the factory into transport planes of the C-87 type capable of flying the longest jump on any route and carrying 7000 pounds of cargo. All of the previously mentioned base points will not average an 8 days' round trip from the production plant. Considering the quantity of spares to be taken out with the original squadron, a full range of spares for any point (figured conservatively at 40,000 pounds) is, therefore, only 24 days away from not 18 depots and sub-depots but 100 or even 200 individual operating squadrons. Taking the original assumed quota of 1000 B-24 type airplanes, this system requires the keeping of less than 350,000 pounds of spares in float between the factory and the point of use, as against the 10,000,000 pounds of spares required under the old system or about 3.5% of the stock otherwise needed just to fill the system.

16. There are, of course, many unknown factors in this picture but the majority of them add to the weight in favor of air transport with small stocks as against surface shipment and large stocks. For one thing, the small pipeline, fast flow, enables control of the flow with greater speed at the source. If landing gear demands exceed expectation and stabilizer needs fall far short of expectation, the character of production requirements can be shifted when only eight days of stocks are accumulated rather than 81 days of stocks. This should save lots of wasted manufacturing effort. Again, small stocks near actual theaters of war present less risk from enemy action than large stocks. Having stocks as mobile as the fighting airplanes themselves enables rapid concentration to meet equivalent concentration of such fighting airplanes.

17. The program is so obvious that it may seem over-simple. However, there are many important factors in its execution. First and foremost, it must fail miserably if the attempt is made to tie it into a large transport system. Decentralization is vital. Transport ships for spare parts supply can be a reserve asset for emergency movement of other cargo on rare occasions; they can serve as ambulance planes on return trips, but they must be regularly and definitely assigned for their main job alone, to a particular squadron. No spare item can psychologically be elevated to a position of first priority until an airplane is on the ground waiting for it. That time is too late. Spares, therefore, cannot fight for their proper place in a huge central airline.

18. Anything short of definite assignment of transport planes to individual squadrons will create a necessity for coordination and an inflexibility of operation which will destroy the main virtue of the idea, direct contact between an operating squadron and the central source of supply.

19. The whole problem has certain similarities to urban store delivery. Large department stores can run deliveries once or twice weekly and ofttimes use centralized parcel delivery services. But the local drug store, which must cater to emergency needs, cannot stay in business without its own boy on a bicycle.

20. Commercial air transport in the United States has been years in building. It cannot today fill the full needs for the movement of spares to the several training points in the United States. It could, but not with greatest efficiency, if used exclusively for that purpose. To expect to build an equally efficient system over night to cover the world and handle all military cargo including aircraft spares under a single system is placing more emphasis on American willingness to take on a job than on the limits of organizational possibility. Decentralization and specialization is the answer.

21. Paralleling such specialization in the air transport of spares, there must be a decentralization and specialization in the handling of spares at point of source in the United States. All shipments direct from the factory would be the most ideal arrangement if adequate space and facilities were available, and if such production plants had no other task but to supply spares for previously delivered aircraft. Such is not the case, however, and production of additional aircraft must continue.

22. Next best solution is the establishment of a single complete warehouse for each type of aircraft to which the production plant can immediately dispatch all spares as soon as produced. This will be the source stock and must be as large and complete as possible. Two such points would merely divide the stock and destroy such a warehouse as a prime source. Since the entire principle being sought is the smallest, fastest pipeline from prime source to point of use, this principle must not be broken by any attempted division of this prime source which can only result in moving the prime source back to the factory where it cannot be adequately handled.

To: AAF Materiel Center — FW:hmc:ff
Attention: General K. B. Wolfe - 7 - 7 January 1943

23. This main warehouse should maintain a full material control record over all parts anywhere in the system. It should be run on a specialized basis by type of aircraft and probably should be run by the particular manufacturer involved. This procedure is not so much suggested because of familiarity of the manufacturer with the parts and with all of the changes and modifications which have taken place in a series of airplanes and which may affect interchangeability, but because the close relationship between the manufacturer and the point of immediate demand for the spares will tend to maintain a better flow of needed spare parts. The manufacturer can and will rob a production line to meet the demands of a crew just in from foreign fields. There is not the same psychological urgency to a depot order. This is important and should not be minimized. The secondary benefit to the manufacturer of being able to watch directly the flow of replacement parts by kind and to learn from that the weaknesses of his particular plane, should not be overlooked.

24. With such a system in effect for world coverage, it becomes apparent that no alternative procedures based upon peacetime methods should be utilized domestically for the relatively few planes in this country being used for training. If the stream of spares to far-off India is to be thinned out and speeded up to cut down the quantity of spares in float, so much more should the stream of spares for Spokane or Milwaukee be thinned out and speeded up for the same reason. If we cannot afford to stock the spares at every point over the world necessary to enable any combat crew to always draw from a plentiful supply at a nearby depot, a fortiori we cannot hope to establish such extravagance for training crews who are at most but a few hours distant from the central warehouse.

25. The job is a big one - one of the largest ever undertaken - but it will be so much smaller by comparison than the wartime extension of the peacetime system of harvest-full warehouses all over the world, that its chances of success should be approached with extreme optimism.

Yours very truly,

CONSOLIDATED AIRCRAFT CORPORATION

Frank Watson
Chief of
Contract Administration

B-24 COMMITTEE

Coordination of B-24 Program:

At the commencement of the B-24 Program calling for the combined efforts of Ford, Douglas, and Consolidated, coordination was handled by direct discussion between company representatives concerned in a particular problem. As the program advanced difficulties arose because of the fact that the Consolidated procedures and plans were different from those used at Ford. These difficulties could not be satisfactorily settled by discussion between company representatives alone, since a solution could be reached only if one of the companies changed their methods to suit the other. Since some of the changes would have involved considerable time and expense each company was reluctant to effect such changes, particularly when it could not be clearly shown whether such a change would actually advance the entire program, or merely delay one company as much as it helped the other.

In order to overcome these conditions the Materiel Command at Wright Field decided to establish a B-24 Committee patterned after the Boeing Douglas Vega Committee for the B-17. This committee was established on 24 March 1942.

The Committee was composed of a member from each company involved who represented management, and were empowered to make commitments on behalf of the company as regards schedules for delivery, data, parts, materials, coordination of subcontracting, tooling, facilities and materials. The Committee in turn appointed various sub-committees to deal with specific items, and report back to the Committee if changes in existing procedures were thought desirable. The sub-committees were Spares Sub-Committee, Tooling Sub-Committee and Engineering Sub-Committee. Because the majority of the difficulties first encountered dealt principally with engineering the Engineering Sub-Committee remained active during the majority of the program; the other committees meeting less often as problems arose. The sub-committees were composed of company employees working in departments directly concerned. These committees worked to see that the directives of the Executive Committee were carried out in detail.

The control value of the B-24 Committee depended to a considerable extent on the active cooperation and assistance of the Army in insisting that agreements reached by the Executive Committee be followed by both companies and Army. While Wright Field representatives on the Executive Committee always supported the decisions taken, difficulties sometimes arose because the various departments at Materiel Command undertook independent actions which undermined or disregarded the program laid out.

These cases were due to failure to inform Army personnel concerned as to the procedure to be followed; not to any intentional desire to break down control. In general, a much improved coordination was achieved and friction between companies was greatly decreased.

The cost in time of the B-24 Committee program was probably but little higher than would have been the case without a committee. Usually it was possible for subcommittee members to carry out the duties of company representatives as well. At the height of the program a number of men were required to cover various items as company representatives. In the particular case of Ford the Contractor furnished a considerable number of engineers to work with Ford at Willow Run. This was caused by an Army request that Ford and North American be allowed to do independent design, however such items are not necessarily a part of the usual committee.

Early in the program an attempt was made to use common tools for fabrication of the power plant. By agreement between companies Fairfax Field was to make tools for all contractors. This proved unsatisfactory because the number of changes being made was so great that the tools were never up to date. In addition this program, as well as the later Interchangeability Program, was hampered by the fact that each company already had tools in production and could not introduce new tools at random. The Interchangeability Program involved a considerable cost in special tooling. However this cost would not have been excessive had the Interchangeability Program been initiated earlier. Since it was started late in the program, it was never completed.

In any future program it would be desirable to inaugurate the committee system at the beginning of the program. The greatest trouble with the B-24 program was that possible difficulties were not foreseen and covered ahead of time. This meant that action was taken only after trouble had occurred and the cost in time and money was considerably higher.

Any future committees should also include specific sub-committees for tooling, inspection, purchasing spares, contracts, etc. as required, as well as engineering. The members of these committees would all work together, preferably in the same offices. The practice of having only one committee is not satisfactory because this committee is primarily interested in only one phase of the program and has no direct control over the methods used in other departments. With committees composed of members from each department of a plant the necessary adaptions to the program can be made by direct consultation between sub-committees without resort to the Executive Committee, as is necessary when a single sub-committee tries to handle work not directly related to its own.

MANAGEMENT

First the Company, then the Corporation, and the Division, but always the men who started the job with additions, changes and subtractions worked continually at the job of getting B-24's to the flight line generally in accord with the everchanging schedules and the original 1938 forecast. And with the ever loyal help of their associate workers at all levels they won all their objectives of delivery date and quantity. Based on this experience they have voluntarily pointed out all of the many things which were wrong during the last war. They have clearly and forcefully set forth how the job can be done quicker and by how much. They have shown how much cheaper the airplane could be built, that is in a very general way. And most important of all they have pointed up all of the things both within and without the company which must be changed to make possible the accomplishment of the objectives of the next war program; namely, the utmost speed of acceleration and the maximum economy of manhours and material. And this is the war record of the management of the San Diego Division, Consolidated-Vultee Aircraft Corporation.

The organization charts show the growth of understanding of the nature of the job and the means necessary to its mastery as it grew in size and complexity. The before, during, and after phases of organization and merger represent not re-organization but the orderly evolution of a very small to a very large organization. This business was exploded rather than expanded. It grew more per month than the average "blue chip" company grows per year of corporate life. As a result a whole generation of personnel changes were compressed into the war period during which time manpower of every classification was critical. Considered from this factual basis, it may be seen that the number of changes actually made were few - not many - and the performance must be rated "superior."

The first line protection for national security lies in this management and supervision "know-how" which was so painfully acquired during the last emergency. This stockpile of knowledge and experience must be protected and increased through the years by means now unknown. This problem is far more of a challenge to the industry and to the Army than is the technological development of the flying weapon itself.

The personal records set forth very clearly the nature and the background of the men who were finally knit together to form the organization which did produce 270 airplanes a month and which could undoubtedly accelerate to that figure in twelve months under proper conditions as stated in the foregoing pages, and which could no doubt produce 500 per month in existing facilities and under proper conditions should they be required.

In considering the performance of the Management of the San Diego Division, attention is invited to three particularly important facts, one, for the first three active years of the project it was an independent company; two, it was one of 14 major operating divisions of the Consolidated-Vultee Aircraft Corporation for more than a year before peak production was reached and three, it was the design prime contractor carrying heavy technical responsibilities for B-24 production at Willow Run, Douglas, North American, and its own affiliate at Fort Worth. While there may have been some advantages accruing to the San Diego program from these factors, it is obvious that benefits were completely lost in the magnitude of the load imposed on the Division Management by the complex situation.

The actual merger of Consolidated and Vultee, taking place during 1942 and early 1943, appears from this date to have resulted not in the conventional reorganization of B-24 management, but rather in its being gradually strengthened and improved as the requirements steadily increased with the expansion of the war program generally.

Many specific illustrations might be introduced to show the quality of corporation management which so definitely affected operations in all of the divisions of Consolidated-Vultee. Perhaps the best for this purpose would be two of the most pertinent, and so copies of a series of national advertisements are presented herewith and left to tell their own story. Also note the brief outline of the Cost Conversion Incentive Plan which worked so well in compensating supervisory employees according to their manner of performance.

COST CONVERSION INCENTIVE PLAN

A brief summary of its purpose and method of administration

1. Purpose - The Cost Conversion Incentive Plan (C.C.I.P.) as installed at the operative divisions of Consolidated Vultee Aircraft Corporation, was installed for the purpose of encouraging supervision to increase production and to decrease operating costs; and also to provide a means of operating and cost control.

2. Method of Administration - The plan was administered by the Industrial Engineering Department, with the assistance of the Accounting Department. Time standards were established, by department, for each item of production; production was in turn converted to man hours of output weekly by multiplying the items produced by this individual unit standard time. This man hour output was then divided by the actual man hour expenditure, or input, for the corresponding weekly period, and the resultant figure was expressed as the "percentage of realization" or efficiency of the department. These weekly efficiency figures were combined to give a period (4 or 5 weeks) or monthly efficiency figure for each department, then totaled to give a plant wide efficiency figure.

The efficiency for the first month was then used as a "Bogey" for the second or succeeding month. A bonus plan, based on this increase efficiency was developed whereby supervision working against standards were paid a cash bonus monthly, the bonus being a percentage of their monthly salary. (All supervision is paid on a monthly flat salary basis.) The formula for bonus percentage calculation is roughly as follows:

1. 10% of "Bogey" if maintained within 3 points.
2. 1/2 of increase over department bogey.
3. A fixed 5% if plant average bogey is maintained within 2 points.
4. 1/2 of increase over plant average bogey.
5. Factors for housekeeping rating, safety (frequency and severity) and conformance to manufacturing schedule.

Example of Bonus Calculation:

Percentage of Realization Factor													
	Department Realization					Plant Realization		Realization Total	Housekeeping factor	Safety factor		Schedule factor	Total %
Depts.	Last Month	This Month	Points Differ-ence	% for meeting bogey	% for improvement	% for meeting Bogey	% for improvement		Penalty only	F.S.		Penalty only	
A	40.	42.	+2	4.0	+1	5.	1.	11.	0	0	0	0	11.
B	50.	54.	+4	5.0	+2	5.	1.	13.	0	0	0	0	15.
C	60.	60.	0	6.0	0	5.	1.	12.	.5	-1	0	0	10.5
D	70.	66.	-4	0	0	5.	1.	6.	-1	-1	+1	0	5.
Plant Average	58.	60.	+2	5.	+1								

Departmental supervisors receive the department % of bonus as shown above, and supervison of more than one department such as General Foremen and Factory Superintendents receive the average bonus of all departments.

THE JOKER IN AIR POWER

EVERY PILOT who wings his Liberator or Fortress over Germany or Japan knows what [illegible] Air Power is.

Every "ground crewman" whose job is to keep a Mustang, Thunderbolt, or Corsair [illegible] fighting trim knows what it is.

Every aircraft engineer who ever saw [illegible] of a wind tunnel knows what it is.

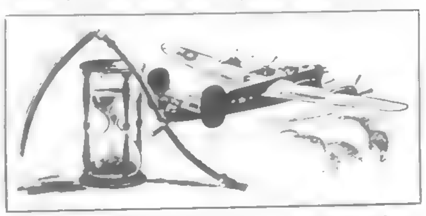
Do you know the joker in Air Power?

It's very important that you should. **For, partly because America forgot it during the prewar years, we came terribly close to losing this war right at the start.**

But now we are winning the war, largely because a few far-sighted men knew what the joker in Air Power was.

So simple—so easy to forget

The joker in Air Power is TIME— the heart-breaking months and years it takes to design, to build, and to perfect a plane to the point where it becomes an efficient, service-tested battle plane, ready for action.



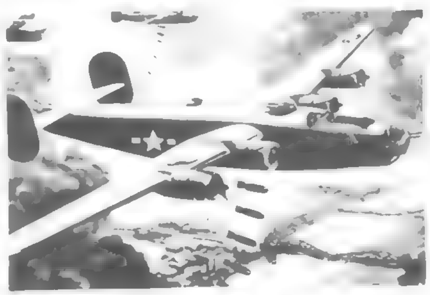
For example, America's first four-engine, long-range bomber was born back in 1934.

But when war was declared, some 7 years later, this bomber was not *even then* ready to go into action as the potent fighting weapon it is today.

True, the first model was flown in [illegible] 193[illegible]. The aircraft engineers knew then that the basic design was good.

But between the first prototype and the current model, **there have been more than 1000 changes, involving over 4 million engineering hours.**

Even by working with desperate speed, it has taken years to smooth out the "bugs" [illegible] Air Forces this heavy long-range bomber [illegible] needed in its most efficient form.



There aren't many short cuts

When the war clouds grew blacker over Europe, the U. S. Army Air Forces came to Consolidated Vultee with the request for still another four-engine heavy bomber.

Shortly afterward, in 1939, the B-24 Liberator was born.

But, even with Consolidated Vultee's long experience in building mammoth sea planes, **it took over 3 years, over 1 million engineering hours, and more than 5 million hours to tool up the plants,** before the Liberator was ready to go into action as one of America's most devastating, heavy bombardment weapons.

Similarly, it took 5 years to develop one of this war's foremost fighter planes from drawing board to final test flight and mass production.

And one of the country's greatest aircraft engines [illegible] and ever since [illegible]

America 1941—a second-rate power

Many other examples could be cited. But [illegible] to drive the point [illegible]

The truth of the matter is that America was caught napping. The nation which invented the airplane was woefully unprepared to defend itself against Axis air power. **We had become a second-rate power in the air.**

And the Axis knew it. They knew that under normal conditions it takes from 3 to 7 years for a plane to progress from drawing board to combat duty.

What they overlooked was the undreamed-of capacity of the American people, and the American aircraft industry, to do the impossible.

Starting almost from scratch, we have been able to design, build and deliver war planes by the tens of thousands [illegible] an armada overwhelming in its might and superiority [illegible] *today.* But remember, the elapsed time has been *[illegible] years!*

"Hot" today—obsolete tomorrow

But in aerial warfare, the nation that depends on mere quantity and present-day superiority of its planes cannot win. That is one reason why Germany lost the Battle of Britain in 1940.

Progress [illegible]

[illegible]

These are facts which an alert America should not, must not forget.

Another fact to keep in mind

[illegible] we are attacked [illegible] be no [illegible] **no time to prepare.**

[illegible] be no other nation [illegible] as Britain did this time, while we [illegible] our power in the air.

An [illegible] attack will most certainly be made with new and even more [illegible] weapons.

We must be ready, and able, to protect ourselves from such attack.

Air Supremacy [illegible] war. **But as long as we maintain our strength in the air, no aggressor nation in its right mind will dare think of attacking us.**

Air Power is Peace Power

The backbone of Air Supremacy [illegible] strong [illegible] competent [illegible] constantly working [illegible] improvement of present [illegible] development of still finer planes.

But we must understand that Air Power is a combination of *all these things:* a postwar Air Force, commercial air transport, a strong supporting aircraft industry with permanent facilities to meet any emergency, widespread personal flying, and a national air-minded way of thinking.

When we understand this, we begin to realize that Air Power can be one of America's soundest investments in the interests of a lasting peace.

LET'S KEEP AMERICA STRONG IN THE AIR!

CONSOLIDATED VULTEE AIRCRAFT CORPORATION

San Diego, Calif.	Tucson, Ariz.	Nashville, Tenn.	Dearborn, Mich.	Miami, Fla.
Vultee Field, Calif.	Fort Worth, Texas	Louisville, Ky.	Allentown, Pa.	Member, Aircraft
Fairfield, Calif.	New Orleans, La.	Wayne, Mich.	Elizabeth City, N. C.	War Production Council

CONVAIR MODEL 37 *Pan American Clipper* · LIBERATOR *4-engine bomber* · LIBERATOR EXPRESS *transport* · CORONADO *patrol bomber* · PRIVATEER *search plane* · CATALINA *patrol bomber* · VALIANT *basic trainer* · SENTINEL *"Flying Jeep"*

Ad No. 210G
American Press—July, 1945
American Agriculturist—July 21, 1945
Dakota Farmer—July 21, 1945
Farmer Stockman—July, 1945
Kansas Farmer, July 7, 1945

Ad No. 210A
Liberty (Ro[illegible])—June 16, 194[illegible]
Pathfinder—May 14, 1945
Newsweek—July 9, 1945
U. S. News—July 20, 1945

Ad No. 210
Life—June 2, 1945

Ad No. 210H
Editor & Publisher, August, 1945

...by the Skin of our Teeth

SEVERAL TIMES during the European phase of this war, victory was almost within Germany's grasp...on land, on the sea, or in the air.

Above all, knowing the vital importance of air supremacy, the Nazis tried time and again to wrest it back from the Allies.

And they almost succeeded.

Time ran out

Especially in the last months of the war, our margin of safety was slimmer than most of us suspected.

Some of our best scientists estimate that if Germany had had a few months longer in which to perfect weapons under development, she could have seriously threatened our ability to win the war.

The truth of this is known best to certain American military experts who have since inspected some of Germany's underground research laboratories and war plants.

Here they saw secret weapons in various stages of development . . . weapons which might conceivably have turned the trick for the Nazis if they could have used them boldly in a last desperate gamble.

Some of these things can now be revealed. Others cannot—yet.

There were planes potentially better than anything the Allies had in combat at that time.

If time hadn't run out on the Germans, quantities of these jet planes might have changed the balance of air power in their favor.

In a V rocket plant, burrowed 800 feet deep in limestone rock, our technicians found blueprints for a fearful V bomb with an estimated range of 3000 miles.

"We planned to destroy New York and other American cities starting in November," said a German rocket engineer.

Target: U. S. A.

In a converted salt mine, our ordnance officers examined nearly completed jet-propelled heavy bombers . . . bombers claimed by the Germans to be capable of crashing high explosives into the industrial cities of the eastern United States and flying back again across the Atlantic.

Goering himself said the planes had been successfully test-flown and would have been in operation if Germany could have held out 3 months longer.

Japan, too, with her ever-improving planes and suicide aerial attacks, tried desperately to whittle down our hard-won air supremacy. But the Japs were no more successful than the Nazis before them had been. The tide had turned.

Why Japan surrendered

Now that victory is ours in the Pacific, many people sincerely believe that it was U. S. air power that brought Japan to her knees.

This, we believe, is not entirely true.

But Japan's defeat points out one lesson that simply can't be argued down: The nation that loses supremacy in the air cannot win a war or remain secure in peace.

Because of this fact, Japan's case was hopeless even before the advent of the atomic bomb. It was only a question of time before she caved in . . . for she had lost control of her skies.

The race we must keep winning

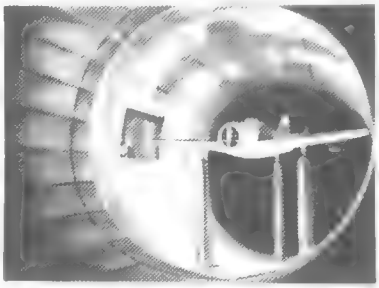
America is now ahead in the development of new aerial weapons.

But there can be no security for us in the future if we rest content on our present day superiority and allow ourselves to lag in aeronautical research and development.

Constant and continuing research in the field of aeronautics is a MUST for America . . . today and always!

As long as we maintain our air superiority after victory, no aggressor nation is apt to be foolhardy enough to dream of attacking us.

But experimental research is only the first step in winning the race that will insure America from attack in the future . . .



The best planes periodically resulting from this research must be put in production in sufficient quantities to develop *manufacturing techniques and tools* and to keep the nucleus of a manufacturing organization which can be quickly expanded if ever needed.

We must also have enough planes for our Armed Services to train the Flight and Ground Crews in their use. *One or two experimental planes are not enough* to keep our Air Force and manufacturing organizations ready for any emergency.

Only when the design and production "bugs" always present in a new plane are revealed and eliminated by use can our ever-improving aircraft be considered *proven* military weapons.

LET'S KEEP AMERICA STRONG IN THE AIR!

CONVAIR MODEL 37 Pan American Clipper | *LIBERATOR* 4-engine bomber | *LIBERATOR EXPRESS* transport | *CORONADO* patrol bomber | *PRIVATEER* search plane | *CATALINA* patrol bomber | *CONVAIR MODEL 110* commercial transport | *SENTINEL* "Flying Jeep"

CONSOLIDATED VULTEE AIRCRAFT CORPORATION

San Diego, Calif. Fairfield, Calif. Fort Worth, Texas Nashville, Tenn. Wayne, Mich. Allentown, Pa. Vultee Field, Calif. Tucson, Ariz.
New Orleans, La. Louisville, Ky. Dearborn, Mich. Elizabeth City, N. C. Miami, Fla.

Member, Aircraft War Production Council

Ad No. 283 B
Newspapers, 640 lines. Sept., 1945

Never forget the A B C of Air Power!

THE NATION that "freezes" the design of its military planes can write off its Air Force as inferior and second-rate.

And, before too long, that nation can write off its Air Force altogether . . . for no second-rate Air Force can long control enemy skies, or even its own.

The Luftwaffe, for example, was beaten because of two things: first, because of overwhelming Allied aircraft *production* . . . and second, because Germany was too late in learning the ABC of Air Power . . .

What is the ABC of Air Power?

The ABC of Air Power is a technique introduced in this war by the Army and Navy and the American aircraft industry.

In simple language it is the technique of making frequent changes in design, during mass production, so that the planes we send into combat *tomorrow* are consistently better than those in combat *today*.

Because America has in this way kept its plane designs fluid, instead of freezing them, our Army and Navy Air Forces, from week to week and month to month, cannot be matched by those of any other nation.

Here's how it works

A company such as Consolidated Vultee starts mass production of a long-range super-bomber—the B-32 Dominator, let us say . . .

The first production-model Dominator to be accepted by the Army Air Forces is probably known as the B-32A.

But in a matter of months—or perhaps weeks—so many changes and improvements have been made in the design of the Dominator that subsequent models are known as the B-32B.

Then come more changes . . . and the B-32C is born. This goes on, right down through the alphabet.

The joker in Air Power

This miracle of constant improvement during mass production—often accomplished **while stopping the assembly lines only momentarily**—sounds like an ideal way to keep an Air Force at peak efficiency. And it is.

But there's another factor to be reckoned with—a factor most people didn't know about in prewar years, or simply overlooked.

That factor is TIME . . . the length of time that elapses between the day a new plane is designed and the day the first model goes into production. And *that* is the joker in Air Power.

The fact of the matter is this: **It takes from 3 to 7 years for a war plane to progress from drawing board to combat action.**

We were caught napping when World War II broke out, because the nation as a whole was unaware of this joker in Air Power.

But, thanks to a few far-sighted Army and Navy officers, and a few members of the aircraft industry itself, we were not caught *totally* unprepared.

A lesson worth remembering

Long before Pearl Harbor, it was obvious that if we ever did go to war against Japan it would be a war in which mobile, floating airfields—flat-tops—would play a dominant part.

So, starting as far back as 1927, the Navy and the aircraft industry began to experiment with carrier-based dive bombers. In 1939—12 years later—the plane born of these experiments was approved for mass production. **But even then, it wasn't ready for combat until 1943!**

Similarly, our finest Navy fighter planes saw combat action for the first time **2 years or more after Pearl Harbor** even though they had been in various stages of development and undergoing test flights long before Japan struck.

It must be clear to every thinking person that when it takes so many heartbreaking months and years to perfect a plane for combat, America must never again invite disaster by lagging behind any nation in aeronautical research and development.

Air Power is Peace Power

Today, no spot on earth is more than 60 hours' flying time from your local airport.

In a world so small, there can be no peace, no security, unless we are prepared to defend ourselves against attack from the air.

That is why constant and continuing **aeronautical research and development**—on the part of the Army, the Navy, and the aircraft industry—is an insurance policy on the life of the nation.

And we must not let a single premium lapse!

LET'S KEEP AMERICA STRONG IN THE AIR!

CONVAIR MODEL 37 Pan American Clipper — *LIBERATOR* 4-engine bomber — *LIBERATOR EXPRESS* transport — *CORONADO* patrol bomber — *PRIVATEER* search plane — *CATALINA* patrol bomber — *VALIANT* basic trainer — *SENTINEL* "Flying Jeep"

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Member, Aircraft War Production Council

Ad No. 277H

Editor & Publisher—Oct. 6, 1945

The airplane that will never be built...

Today ... [illegible]

... that of sound itself.

Helicopters ... hover motionless in mid-air ... backwards.

... planes whose wingspread ... Kitty Hawk.

Tomorrow: higher, faster, farther

You've probably seen pictures of even more startling planes that are on the way now that peace is here . . .

Grotesque, bat-like "flying wings" . . . double- and triple-decker stratosphere transports in which several hundred passengers ... from the U. S. to Europe in a few hours . . . ... highway as a car, or take to the air on wings.

Planes ... will be ... that w...

A plane you'll never see

We predict that you'll never see a ... and say, "This is the last word ... the *ultimate in airplanes.*"

There will never be such a plane. **For man's conquest of the air has always been, and always will be, a *continuing* challenge to his ingenuity.**

... mental laboratories, or undergoing test flights.

True, under the impetus of war, aeronautical research and knowledge have advanced perhaps as much as 10 or even 20 years, almost overnight.

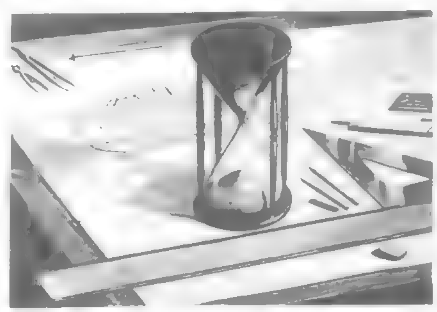
But this fact has only *increased* the challenge which must be met by any nation which hopes to achieve and maintain air supremacy.

Flying on borrowed time

We ... not, ever ... forget the lessons this war has ...

We *did* forget after World War I. ... and became a second-rate power ... For example ...

And even as late as 1928, ... planes were still being designed and built for ... power plant!



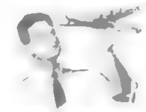
Today America ... If we maintain that superiority it can become our best insurance against future attack by aggressor nations, and for an enduring peace. ...

A new tool for air supremacy

... has now given us a new ... one of the most advanced wind tunnels ever built in America, perhaps in all the world.

...

Research only the first step



The work that will go on in this new wind tunnel is only the first step in insuring America from attack from the air in the future.

The best planes resulting from this research must be put into production ... so that ... can be perfected . . . ... can be rapidly expanded in case of another national emergency.

Our armed services cannot train flight and ground crews in the use of a new plane ... exist. Nor can design and production "bugs" ... in a new plane, be eliminated by building only a few experimental models.

And so, in the future as in the past, it is the hope of the aircraft industry that ... can be dedicated to designing, developing, and building reasonable quantities of ever-improving aircraft so that America will never again lack *proved* military aerial weapons.

LET'S KEEP AMERICA STRONG IN THE AIR!

CONSOLIDATED VULTEE AIRCRAFT CORPORATION

San Diego, Calif. / Vultee Field, Calif. / Fairfield, Calif. — Tucson, Ariz. / Fort Worth, Texas / New Orleans, La. — Nashville, Tenn. / Louisville, Ky. / Wayne, Mich. — Dearborn, Mich. / Allentown, Pa. / Elizabeth City, N. C. — Miami, Fla. / Member, Aircraft War Production Council

CONVAIR MODEL 37 Pan American Clipper — LIBERATOR 4-engine bomber — LIBERATOR EXPRESS transport — CORONADO patrol bomber — PRIVATEER search plane — CATALINA patrol bomber — CONVAIR MODEL 110 commercial transport — SENTINEL "Flying Jeep"

Life November 5, 1945
Saturday Evening Post November 10, 1945

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
LARSEN, ARTHUR V.	3-1-43	To Date

POSITION AT CVAC	FROM	TO
Director of Purchasing	3-1-43	8-31-44
Purchasing Director	9-1-44	To present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
U. S. Maritime Comm.		Head of Mat. Br.	6-42	2-20-43
Brunswick-Balke-Collender Co.	Muskegon, Mich.	Director of Purchases	5-41	5-42
Gen. Motors-Chev. Div.	Flint, Michigan	Asst. Pur. Agent	1923	1941

NAME	HIRED	TERMINATED
JONES, EDWARD HERMAN	10-14-29	To Date

POSITION AT CVAC	FROM	TO
Chief of Materials	5-16-40	6-15-41
Material Control Supervisor	6-16-41	9-15-42
Chief of Materials	9-16-42	3-15-44
Assistant to Purchasing Director	3-16-44	9-15-45
Chief of Materials	9-16-45	To Date

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Clerk	10-14-29	3-16-34
Material Clerk	3-19-34	7-12-35
Clerk	8-1-35	12-18-36
Assistant Purchasing Agent	12-19-36	9-15-38
Chief of Materials	9-16-38	See above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
General Aircraft Corp.	Buffalo, N. Y.	Stock Clerk	6-1926	10-1926

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
NELSON, ALBIN SIGFRED	5-20-35	9-25-45

POSITION AT CVAC	FROM	TO
Assistant Purchasing Agent	8-1-37	6-15-41
Purchasing Agent	6-16-41	3-15-44
Chief Purchasing Agent	3-16-44	3-31-44
Chief of Material	4-1-44	9-25-45

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Stock Clerk	5-20-35	7-26-35
Clerk	8-1-35	7-31-37

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Minnesota Mine & Mfg. Co.	St. Paul, Minn.	Sales-Ofc.Mgr.	2-1927	4-1935
Twin City Railroad	St. Paul, Minn.	Surveyor	1925	1927

NAME	HIRED	TERMINATED
LEIGH, CHARLES THOMPSON	5-16-26	To Date

POSITION AT CVAC	FROM	TO
Vice President and Material Supervisor	8-31-35	12-19-41
Vice President and Assistant General Manager	12-20-41	To present time

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Constr. Supt.	5-16-26	11-1927
Genl Manager (Tonawanda Products)	11-1927	6-1932
Purchasing Agent	6-1-32	8-31-35

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Gray's Harbor Constr. Co.	Hoquiam, Wash.	Superintendent	1921	1926

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME		HIRED	TERMINATED
FARRELL, FREDERICK		10-15-42	2-10-43
	Rehired	4-23-43	10-15-45

POSITION AT CVAC	FROM	TO
Service Engineer	10-15-42	2-10-43
Administrative Assistant	4-23-43	11-15-43
Asst. to Chief of Contracts	11-16-43	5-31-45
Chief of Contracts	6-1-45	Present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Flameproofing Prod. Co.	San Diego, Calif.	Partner-Mgr.	11-41	10-42
United Services Life Ins.		Supervisor	6-39	11-41
U. S. Navy		Commissioned Line Officer	6-15	1-39

NAME	HIRED	TERMINATED
MUSSEN, ROBERT LEE	1-3-29	To Date

POSITION AT CVAC	FROM	TO
Estimater	7-1-37	4-13-42
Supervisor (Estimating)	4-14-42	6-30-43
Chief of Contract Admin.	7-1-43	3-15-44
Chief of Contracts	3-16-44	5-31-45
Assistant Division Manager	6-1-45	To present time

POSITION AT CVAC PRIOR TO 1939	FROM	TO
Assembly Helper	1-3-29	1-11-30
Fuselage Assembler	1-12-30	11-10-33
Dispatcher	11-13-33	6-30-37

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
American Brass Co.	Buffalo, N. Y.	Clerk	1928	1929
Motor Prod. Co.	Detroit, Mich.	Clerk	1927	1928

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
McMAHON, RAYMOND JOSEPH	9-24-41	6-30-45

POSITION AT CVAC	FROM	TO
Contract Administrator	9-24-41	4-14-43
Chief of Contract Administration	4-15-43	6-30-44
District Manager (Allentown)	7-1-43	8-15-44
Asst. to Director of Purchasing	8-16-44	6-30-45

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Navy Dept. Bureau of Aero.	Washington, D. C.	Asst. I.N.A. & Naval Aviator	9-1935	9-1941
Howitt-Wood Radio Corp.	Arlington Hotel Binghamton, N. Y.	Announcer, writer and actor	9-1933	8-1935

NAME	HIRED	TERMINATED
LEARMAN, FRANK A.	9-10-29	To Date

POSITION AT CVAC	FROM	TO
Assistant to Manager	2-1-38	2-28-42
General Sales Manager	3-1-42	To present time

POSITION AT CVAC PRIOR TO 1939	FROM	TO
No Classification	9-10-29	3-17-32
Assistant Project Engineer	3-17-32	8-15-35
Draftsman	8-16-35	2-15-36
Assistant Manager	2-17-36	See Above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Hall Alum. Aircraft	Buffalo, New York	Engineer	1928	1929
G. Elias & Brother	Buffalo, New York	Engineer	1927	No Date

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
VanDERVEER, THEODORE W.	4-1-42	To Date (Deceased)

POSITION AT CVAC	FROM	TO
Asst. to the Plant Engineer	4-1-42	7-15-42
Administrator	7-16-42	11-30-42
Plant Engineer	12-1-42	3-15-44
Chief Plant Engineer	3-16-44	To present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Auto Ventshade Co.	Jacksonville, Fla.	Secretary-Treas.	5-1-39	4-42
Glidden Co.	Jacksonville, Fla.	General Supt.	12-1-37	5-15-39
Glidden Co.	Cleveland, Ohio	Dir. of Eng.	3-15-37	12-1-37
National Aniline & Chem.	Buffalo, N. Y.	Asst. Plant Mgr.	10-1-21	3-15-37
U. S. Army	Picatinny Arsenal, New Jersey	Chief Eng. Div.	1-1-20	8-1921
U. S. Army	Field Artillery	1st Lieut.	8-27-17	10-29-19

NAME	HIRED	TERMINATED
HYARD, HERBERT	3-9-28	To Date

POSITION AT CVAC	FROM	TO
Foreman	5-11-35	10-18-40
General Factory Supt.	10-19-40	2-28-42
Factory Manager	3-1-42	3-15-44
Works Manager	3-16-44	7-15-45
Division Works Manager	7-16-45	Present time

POSITION AT CVAC PRIOR TO 1939	FROM	TO
Layout Foreman	3-9-28	7-15-29
General Foreman	7-15-29	11-2-30
Layout Foreman	11-3-30	7-21-33
Expr. Foreman	7-24-33	3-18-34
Asst Foreman	3-19-34	5-11-35

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EZARD, HERBERT (Continued)

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Wire Wheel Corp. of Am.		Asst. Foreman	1918	3-28
Curtiss Airplane Co.	Buffalo, N. Y.	Foreman	1916	1918
Crause-Hinds	Syracuse, N. Y.	Patternmaker	1914	1916
Syracuse Car Works	Syracuse, N. Y.	Template Mkr.	1913	1914

NAME	HIRED	TERMINATED
MALONEY, WILLIAM ALOYSIUS	9-10-35	To Date

POSITION AT CVAC	FROM	TO
Plant Engineer	9-10-35	11-30-42
Chief, Works Engineer	12-1-42	7-15-43
Plant Engineering Director	7-16-43	To present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Bemunt Cander	Buffalo, N. Y.	Elec. Engineer	6-1-28	8-31-35
Buffalo Switchboard Co.	Buffalo, N. Y.	Sec.-Treas.	5-1-26	6-26-27
Cleveland Switchboard Co.	Cleveland, Ohio	N. Y. Engineering Representative	7-1-21	4-4-26
Bison Elec. Co.	Buffalo, N. Y.	Salesman	11-1-19	6-20-21

NAME	HIRED	TERMINATED
BOWLING, HERBERT	1-26-25	5-31-45

POSITION AT CVAC	FROM	TO
Foreman	8-16-35	9-30-40
General Factory Superintendent	10-1-40	10-3-41
Assistant Factory Manager	10-4-41	2-28-42
Factory Manager - Plant One	3-1-42	3-31-43
Production Works Manager	4-1-43	2-15-44
Division Works Manager	2-16-44	5-31-45

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

BOWLING, HERBERT (Continued)

POSITION AT CVAC PRIOR TO 1939	FROM	TO
Foreman	1-26-25	3-16-34
Assistant Foreman	3-19-34	See Above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Curtiss Aeroplane Co.	Buffalo, N. Y.	Assembler	1915	1921

NAME	HIRED	TERMINATED
[illegible]Y, JAMES LEO	1-1-29	To Date

POSITION AT CVAC	FROM	TO
Factory Manager	11-1-38	2-29-42
Assistant Vice President - Production	3-1-42	6-15-43
Division Manager	6-16-43	To Date

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Superintendent	1-1-29	3-16-34
Foreman	3-19-34	10-27-34
Assistant Superintendent	10-29-34	1-12-35
Superintendent	1-14-35	8-30-35
Factory Superintendent	No Date	10-31-38

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

No record of previous employment.

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
PERELLE, CHARLES WILLIAM	8-15-40	9-1-44

POSITION AT CVAC	FROM	TO
Factory Manager (Vultee Field)	8-15-40	12-31-40
Division Manager " "	1-1-41	3-1-42
Vice President In Charge of Production	3-1-42	9-1-44

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

No Record of previous employment.

NAME	HIRED	TERMINATED
LADDON, ISAAC MACHLIN	3-15-27	To Date

POSITION AT CVAC	FROM	TO
Vice President and Chief Engineer	8-21-35	12-19-41
Vice President and General Manager	12-20-41	2-28-42
Executive Vice President and General Manager	3-1-42	To present time

POSITION AT CVAC PRIOR TO 1939	FROM	TO
Engineer	3-15-27	8-20-35
Vice President and Chief Engineer	8-21-35	See above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
U. S. Air Service	McCook Field	Engineer	1917	1927
Cadillac Motor Co.	Detroit, Mich.	Engineer and Draftsman	1915	1917

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
VanD[illegible], C[illegible] ALBERT	12-10-34	1-16-42
POSITION AT CVAC	FROM	TO
Vice President Works Manager	8-16-35	1-16-42
POSITION AT CVAC PRIOR TO 1939	FROM	TO
Factory Manager	12-10-34	8-16-35

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM TO
Glenn L. Martin	Buffalo, N. Y.	Vice President & General Manager	Period of 21 yrs.

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
TUTTLE, WILLIAM GERARD	7-1936	To Date

POSITION AT CVAC	FROM	TO
Director Industrial Relations (Vultee Field)	3-15-36	3-15-44
Chief of Industrial Relations (San Diego)	3-16-44	To present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Ford Motor Company	Richmond, Calif.	Personnel Director	4-1932	7-1936
Union Oil Company	Portland, Oregon	Personnel Superv.	10-1930	3-1932
Union Oil Company	Oleum, Calif.	Personnel Superv.	3-1928	9-1930
Union Oil Company	Brea, Calif.	Derrick Man and Oil Scout	5-1925	3-1928
Sigourney Meller & Co.	New York City and Philadelphia	Salesman and Mgr. New York Office	6-1922	3-1925

NAME	HIRED	TERMINATED
PERSONS, WILLIAM FRANK	4-9-42	4-2-43

POSITION AT CVAC	FROM	TO
Industrial Relations Director	4-9-42	4-2-43

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Civilian Conservation Corps	Federal Security Agency, Wash., D. C.	Asst. Director	11-1-39	4-9-42
U. S. Department of Labor	Director U. S. Employment Service	Director	7-1-33	9-30-39

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
PARKHURST, RAYMOND BYRON	8-9-40	9-1-45

POSITION AT CVAC	FROM	TO
Chief Industrial Engineer (Vultee)	8-9-40	3-42
Administrator	3-16-42	8-31-42
Chief Industrial Engineer	9-1-42	7-15-43
Industrial Engineering Direction	7-16-43	9-15-44
Assistant to the President	9-16-44	9-1-45

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
General Electric Co.	Schenectady, N. Y.	No Position Shown	1917	1940

NAME	HIRED	TERMINATED
LAMPKIN, WILLIAM WALTER	6-21-40	To Date

POSITION AT CVAC	FROM	TO
Industrial Engineer	6-21-40	4-3-43
Assistant Chief Industrial Engineer	5-1-43	2-29-44
Chief Industrial Engineer (Nashville)	2-30-44	11-30-44
Assistant to Division Manager	12-1-44	5-15-45
Chief Industrial Engineer (San Diego Div.)	5-16-45	To present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Davis Standard Bread Co.	Los Angeles, Calif.	Salesman	6-39	6-40
Commonwealth of Penn.	Liquor Control Board Harrisburg, Pa.	Clerk & Bkkpr.	12-36	6-39
Self: Indust. Surveys	Philadelphia, Pa.	Consultant	11-31	10-36
The May Co.	Los Angeles, Calif.	Clerk	8-27	9-29
Metropolitan Life Ins.	Huntington Park, Calif.	Agent	10-29	9-31

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
DRULINER, JOSEPH MURRAY	6-1935 3-21-41	11-1935 5-15-45

POSITION AT CVAC	FROM	TO
Chief Industrial Engineer (Nashville Division)	3-24-41	12-31-43
Chief Industrial Engineer (San Diego)	1-1-44	5-15-45

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Sheet Metal Mechanic	6-1935	11-1935

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
North American Aviation, Inc.	Inglewood, Calif.	Asst. Foreman and Sr. Methods Engr.	2-1936	3-1941
U. S. Army Air Corps	-	Sheet Metal Mech.	11-1935	2-1936
Catalina - Wilmington Airlines	Catalina, Calif.	General Mechanic	1-1935	6-1935
Northrop Air. Corp.	Inglewood, Calif.	Sheet Metal Worker	1-1933	6-1935
Douglas Aircraft Co.	Santa Monica, Cal.	Sheet Metal Mech.	8-1930	1-1933

NAME	HIRED	TERMINATED
DOCKSTADER, CLAYTON ROSS	7-1-40	To Date

POSITION AT CVAC	FROM	TO
Asst. to Exec. Vice President (Nashville Div.)	7-1-40	1-15-44
Asst. Director of Industrial Engineering	1-16-44	To present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

See above

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
STEWART, EDMOND THORNE	2-15-37	To Date

POSITION AT CVAC	FROM	TO
Chief Storekeeper	5-16-40	10-15-41
Assistant Supervisor Production Control	10-16-41	1-16-42
Production Control Supervisor	1-17-42	12-15-42
Assistant Production Supervisor	12-16-42	3-30-43
Production Supervisor	4-1-43	3-15-44
Production Control Superintendent	3-16-44	To Date

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Final Parts Stock Clerk	2-15-37	7-31-37
Storekeeper	8-1-37	8-31-37
Chief Storekeeper	9-1-37	See Above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
U. S. Navy	-	Lt. Supply Corps.	1917	6-30-36

NAME	HIRED	TERMINATED
HENSON, JR., WILLIAM H.	2-24-36	7-15-45

POSITION AT CVAC	FROM	TO
Estimator	7-11-37	2-28-42
Cost Estimating Supervisor	3-1-42	4-13-42
Production Supervisor	4-14-42	3-31-43
Assistant Division Manager	4-1-43	4-30-45
Division Works Manager	5-1-45	7-15-45

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Estimator	2-24-36	See Above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Navy Dept. Bureau of Aero.	Washington, D. C.	Est. & Cost Engr.	8-4-34	2-1936
B. J. Aircraft	Baltimore, M. D.	Engineer Charge	1929	8-1-34
Kreider-Reisner Aircraft	Hagerstown, Md.	Plan. & Est.	1-1929	8-1929
P[illegible]al Aircraft Factory	Philadelphia, Pa.	Stress Analysis	1928	3-1929

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
NELSON, WILLIAM	10-2-41	Trans. to New Orleans

POSITION AT CVAC	FROM	TO
Assistant to Manager	10-2-41	12-19-41
Material Supervisor	12-20-41	9-31-42
Production Representative	10-1-42	12-31-42
Works Manager of New Orleans Division	1-1-43	-

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
U. S. Navy	-	Captain	9-2-11	10-1-41

NAME	HIRED	TERMINATED
MAYER, ROLAND GEORGE	5-7-40	12-1-42 Trans. Ft. Worth

POSITION AT CVAC	FROM	TO
Production Control Manager	5-7-40	2-28-42
Production Coordinator	3-1-42	

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
U. S. Navy	-	Commander	22 Years	

NAME	HIRED	TERMINATED
DEMARCE, RONALD RAYMOND	12-2-29	To Date

POSITION AT CVAC	FROM	TO
Inspector	5-16-40	2-15-41
Assistant Chief Inspector	2-16-41	7-31-41
Chief Inspector	8-1-41	1-15-43
Chief of Inspection	1-16-43	Present Time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Curtiss Aircraft Co.	Buffalo, N. Y.	Inspector	1927	1929
A. M. Dist. Steam	N. Tonawanda, N. Y.	Pur. Agent	No Dates	

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME

DEMARCE, DONALD RAYMOND (Continued from previous page)

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Pecost Oil	N. Pennsylvania, W. Y.	Sales	No dates	

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Inspector (Buffalo - San Diego)	12-2-29	5-15-40

NAME	HIRED	TERMINATED
MARTIN, HAROLD SMITH	10-14-40	To Date

POSITION WITH CVAC	FROM	TO
Aeronautical Engineer	10-14-40	12-31-40
Assistant to Manager	1-1-41	2-28-42
Quality Manager	3-1-42	To present time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Nat. Div. Air Corps	Wright Field Dayton, Ohio	Project Engineer	5-6-39	10-11-40
Pan Am. Grace Airways	Lima Peru, So. Am.	Maint. Engineer	2-6-35	12-31-37
Penn. Air Lines	Pittsburgh, Pa.	President	6-1-31	8-20-34
Pgh. Aviation Ind. Corp.	Pittsburgh, Pa.	Vice President	7-1-29	5-31-31
U. S. Army	-	Army Officer	3-1-09	6-30-29

NAME	HIRED	TERMINATED
THOMPSON, JOHN CLARK	9-8-24	1-15-43

POSITION WITH CVAC	FROM	TO
Chief Inspector	9-8-24	2-28-42
Chief of Inspection	3-1-42	1-15-43

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

No record of previous employment.

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
FLEET, R. H.	5/20-23	To Date

POSITION AT CVAC	FROM	TO
President & General Manager	5-29-23	2-28-42
Consultant	3-1-42	Present Time

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

No record of previous employment.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
SHEAHAN, BERNARD WILLIAM	3-21-27	To Date

POSITION WITH CVAC	FROM	TO
Engineer in Charge Drafting	5-16-40	11-30-41
Assistant Chief Engineer	12-1-41	3-31-42
Executive Assistant Chief Engineer	4-1-42	7-31-42
Engineering Manager	8-1-42	To present time

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
No position shown	3-21-27	7-15-34
Chief Engineer	7-16-34	8-16-35
Engineer in Charge Drafting	8-1[illegible]-35	See above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
U. S. Air Corps	Dayton, Ohio	Project Engineer	1918	1927
Elgin Motor Co.	Chicago, Ill.	Designing	1916	1917
H. L. Lozier Motor	Cleveland, Ohio	Designing	1915	1916
Ferro Machine Co.	Cleveland, Ohio	Designing	1911	1915

NAME	HIRED	TERMINATED
SUTTON, HARRY ALLEN	9-16-35	12-31-44

POSITION AT CVAC	FROM	TO
Assistant to Chief Engineer	2-1-38	2-28-42
Chief Engineer	3-1-42	5-31-43
Director Engineering	6-1-43	12-31-44

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Assistant Chief Engineer	9-16-35	1-31-38

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Curtiss Aircraft	Buffalo, N. Y.	Engineer	1932	1935
Aviation Corp.	Buffalo, N. Y.	Engineer	1929	1931
U. S. Army Air Corps	Buffalo, N. Y.	Engineer	1917	1929

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
FINK, FRANK W.	9-5-35	To Date

POSITION AT CVAC	FROM	TO
Project Engineer	3-16-39	11-30-41
Chief Project Engineer	12-1-41	3-31-42
Assistant Chief Engineer Production	4-1-42	7-31-42
Chief Production Engineer	8-1-42	6-15-43
Chief Division Engineer	6-16-43	Present time

POSITION AT CVAC PRIOR TO 1939	FROM	TO
Engineer	9-5-35	7-15-38
Assistant Project Engineer	7-16-38	3-15-39

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Curtiss Aero. & Motor Company	Buffalo, New York	Engineer	8-16-26	8-16-35

NAME	HIRED	TERMINATED
BOETTIGER, WILFRED OTT	9-21-42	9-30-45

POSITION AT CVAC	FROM	TO
Staff Assistant	9-21-42	3-31-44
Sub-Contract Ass't. Superintendent	4-1-44	5-15-44
Sub-Contract Superintendent	5-16-44	9-30-45

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Columbia Steel Co.	Los Angeles, Cal.	Salesman and Engineer	5-1936	9-1942
Santa Fe Irrig.	Rancho Santa Fe, California	Manager	5-1924	5-1936
C. M. & St. P. Ry. Co.	Chicago, Illinois	Asst. Engineer	5-1919	3-1923
Santa Fe Land Imp. Co.	Rancho Santa Fe, California	Engineer	4-1923	5-1924
Gary Land Co.	Gary, Ind.	Field Engineer	9-1918	5-1919

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME		HIRED	TERMINATED
GOLEM, HOWARD GUSTAV		12-10-29	5-15-44
	Rehired	1-1-45	To Date

POSITION AT CVAC	FROM	TO	
Traffic Manager & Asst. Material Supervisor	9-16-38	6-12-42	
Supervisor of Sub-Contract	6-13-42	5-14-43	
Chief of Sub-Contracting	5-15-43	5-15-44	Terminated
Assistant Purchasing Agent	1-1-45	9-15-45	
Chief Purchasing Agent	9-16-45	Present Time	

POSITION AT CVAC PRIOR TO 1939	FROM	TO
Clerk (Office) - (Tonawanda Products)	12-10-29	3-19-34
Material Clerk	3-19-34	8-30-35
Traffic Clerk	8-30-35	9-15-38

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Southern Aircraft Corp.	Garland, Texas	Vice-President-in-Charge-of-Mfg.	5-44	1-45
Central Mk. State Trust	Buffalo, New York	Bookkeeper	6-29	12-29
Buffalo Bolt Co.	Buffalo, New York	Machine Opr.	No dates	

NAME	HIRED	TERMINATED
GARBACZ, GEORGE FRANCIS	11-19-35	To Date

POSITION AT CVAC	FROM	TO
Leadman	5-7-39	6-30-40
Night Foreman	7-1-40	5-31-41
Tool Processor	6-1-41	4-24-42
Process Engineer	4-25-42	7-15-42
Section Supervisor - Process Engineering	7-16-42	7-31-42
Superintendent - Tool Room	8-1-42	3-31-43
Assistant Chief Tool Engineer	4-1-43	1-31-45
Chief Tool Engineer	2-1-45	Present Time

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Toolmaker	11-19-35	9-25-37
Leadman	9-26-37	6-18-38
Toolmaker	6-19-38	5-6-39

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

GERHAUSER, GEORGE FRANCIS (Continued from previous page)

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
R. C. A. Mfg. Co.	Hollywood, Calif.	Toolmaker	1-1935	3-1935
Landis Machine Co.	St. Louis, Mo.	Toolmaker	11-1933	8-1934
Fox Studio	Westwood, Calif.	Camera Tech.	9-1932	9-1933

NAME

MYERS, ELI PAUL

HIRED 7-1-42

TERMINATED 1-31-45

POSITION AT CVAC

	FROM	TO
Planning Supervisor	7-1-42	9-15-42
Tooling and Planning Chief	9-16-42	10-15-42
Chief Tool Engineer	10-16-42	1-31-45

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
A. J. Brandt Co.	Detroit, Mich.	Consultant	7-1941	7-1942
Paramount Engineering	Detroit, Mich.	Tool Engineer	7-1939	7-1941
Pranur Engineering	Detroit, Mich.	Tool Engineer	8-1938	7-1941
General Motors	Flint, Michigan	No Position Shown		5 years
Marvel Carbare	Flint, Michigan	No Position Shown		3 years

NAME

GWINN, JR., JOSEPH MARR

HIRED 1923
Rehired 7-16-40

TERMINATED 8-31-35
To Date

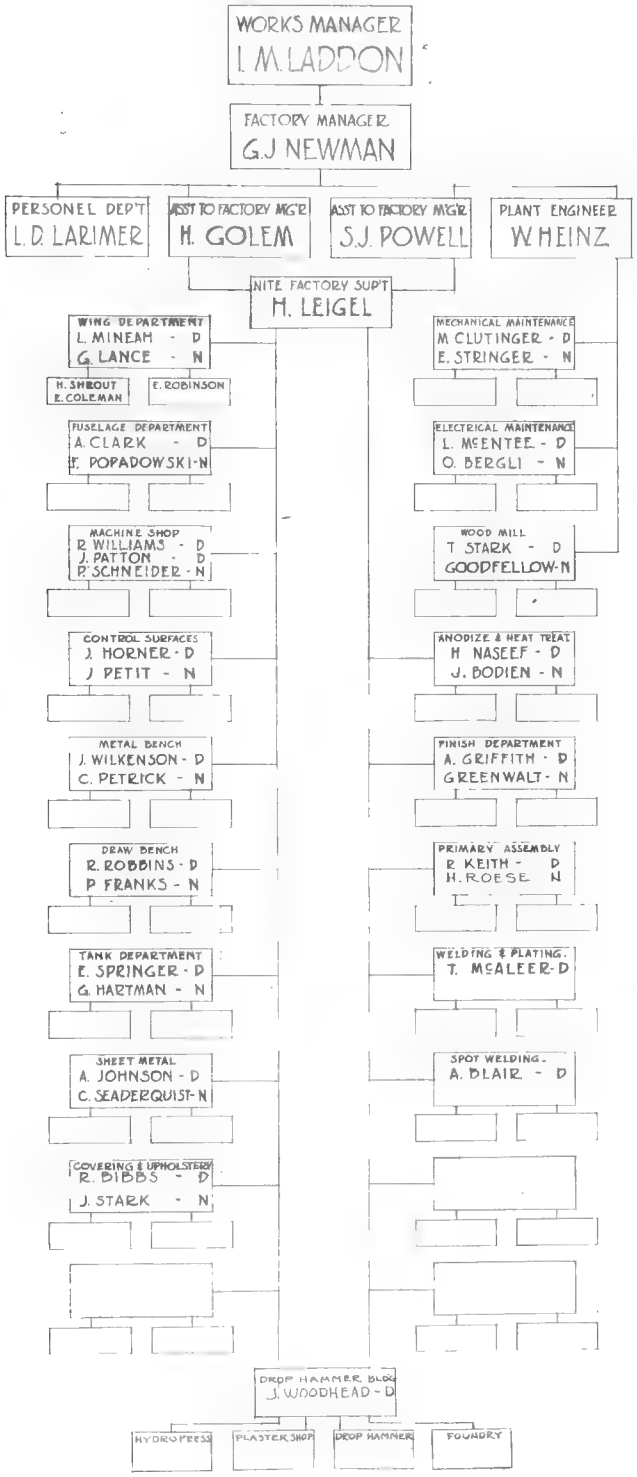
POSITION AT CVAC

	FROM	TO
Production Engineer	7-16-40	2-28-42
Chief of Production Engineering	3-1-42	4-13-42
Supervisor - Tooling & Methods	4-14-42	7-15-43
Tooling Director	7-16-43	11-5-44
Division Manager - Stout Research	11-6-44	To Date

POSITION WITH CVAC PRIOR TO 1939

	FROM	TO
Engineer	1923	8-31-35 Resigned

FACTORY ORGANIZATION CHART
PARTS PLANT



Original Organization Chart of Plant II

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

GWINN, JR., JOSEPH MARK (Continued from previous page)

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Bell Aircraft Corp.	Buffalo, N. Y.	Chief Project Engineer	9-1939	7-1940
Brewster Aero. Corp.	Long Island, N. Y.	Consulting Engineer	5-1939	9-1939
Gwinn Aircar Company	Buffalo, N. Y.	President	9-1935	1940

NAME

KOENIG, PHILIP

	HIRED	TERMINATED
	1-2-28	3-17-44
Rehired	8-28-44	10-17-44

POSITION AT CVAC

	FROM	TO
Tool Supervisor	5-1-37	10-15-42
Tool Consultant	10-16-42	2-13-43
Tool Supervisor (New Orleans)	2-15-43	3-17-44
Foreman - Group V	8-28-44	10-17-44 (Resigned)

POSITION AT CVAC PRIOR TO 1939

	FROM	TO
Machine Shop Foreman (Tonawanda Products)	1-2-28	8-14-33
Foreman	8-14-33	3-16-34
Assistant Foreman	3-19-34	8-16-35
Chief Tool Designer	8-16-35	7-31-37

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Flexlume Sign Co.	Buffalo, N. Y.	Foreman	No dates	

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME	HIRED	TERMINATED
LAWSON, ROBERT ALEX	2-16-40	6-15-45

POSITION AT CVAC	FROM	TO
Night Superintendent (Vultee Aircraft - Downey, Calif.)	2-16-40	9-15-40
Factory Superintendent " "	9-16-40	1-15-41
Asst. Works Manager " "	1-16-41	5-31-41
Works Manager " "	6-1-41	3-31-43
Factory Manager (S. D. Division)	4-1-43	2-15-44
Assistant Division Works Manager - Plant I	2-16-44	12-31-44
Works Manager - Plant I	1-1-45	6-15-45

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

EMPLOYER	ADDRESS	POSITION	FROM	TO
Aircraft Precision Prod.		Chief Engineer in Charge of Prod.	8-1938	2-1940
Douglas Aircraft Co.		Shop Eng. in Chg.	6-1934	8-1938
George F. Lawson & Son		Owner & Manager	8-1930	8-1933
Gillette Safety Razor Co.		Automatic Machines Designer	6-1929	8-1930
B. F. Sturtevant Co.		Designer & Shop Project	6-1926	6-1929

NAME	HIRED	TERMINATED
GOLEN, HENRY R.	10-1-27	To Date

POSITION AT CVAC	FROM	TO
Foreman	5-16-40	6-15-41
Equipment Supervisor	6-16-41	7-31-41
Assistant to Factory Manager	8-1-41	4-3-42
Assistant Factory Manager	4-4-42	2-29-44
Assistant Works Manager - Plant II	3-1-44	To Present Time

POSITION WITH CVAC PRIOR TO 1939	FROM	TO
Superintendent	10-1-27	3-16-34
Foreman	3-19-34	See above

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

No record of Previous Employment

COPY

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego Division . . San Diego, California

NAME

[redacted], GEORGE J.

	HIRED	TERMINATED
	10-29-24	5-11-44

POSITION AT CVAC

	FROM	TO
Asst. Factory Manager	11-1-38	2-28-42
Vice-President in Charge Ft. Worth Division	3-1-42	5-11-44

POSITION AT CVAC PRIOR TO 1939

	FROM	TO
Superintendent	11-1-30	3-16-34
Foreman	3-19-34	7-26-35
Asst. Supt.	8-1-35	10-31-38

BUSINESS BACKGROUND BEFORE ENTERING COMPANY

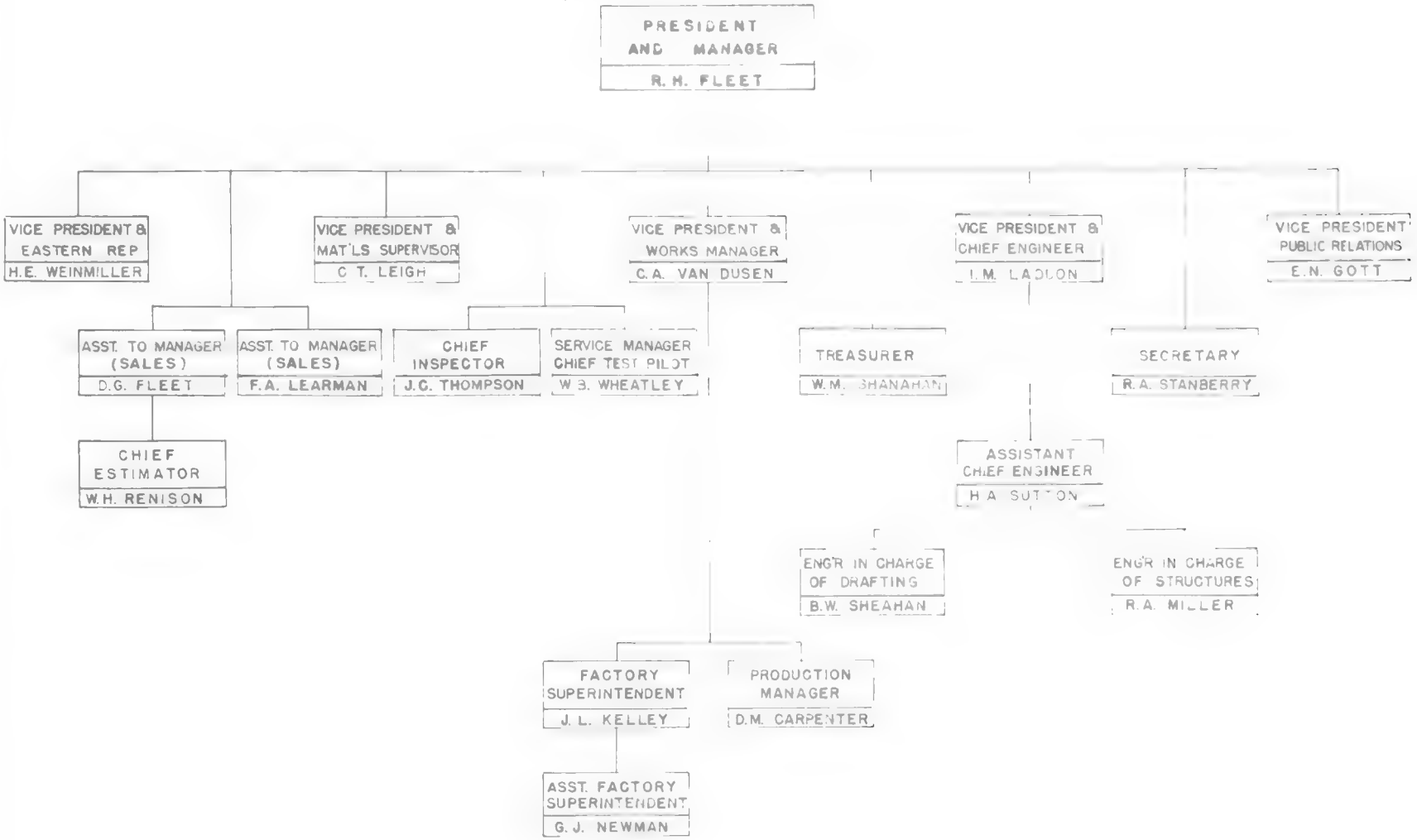
EMPLOYER	ADDRESS	POSITION	FROM	TO
(No record of previous employment)				

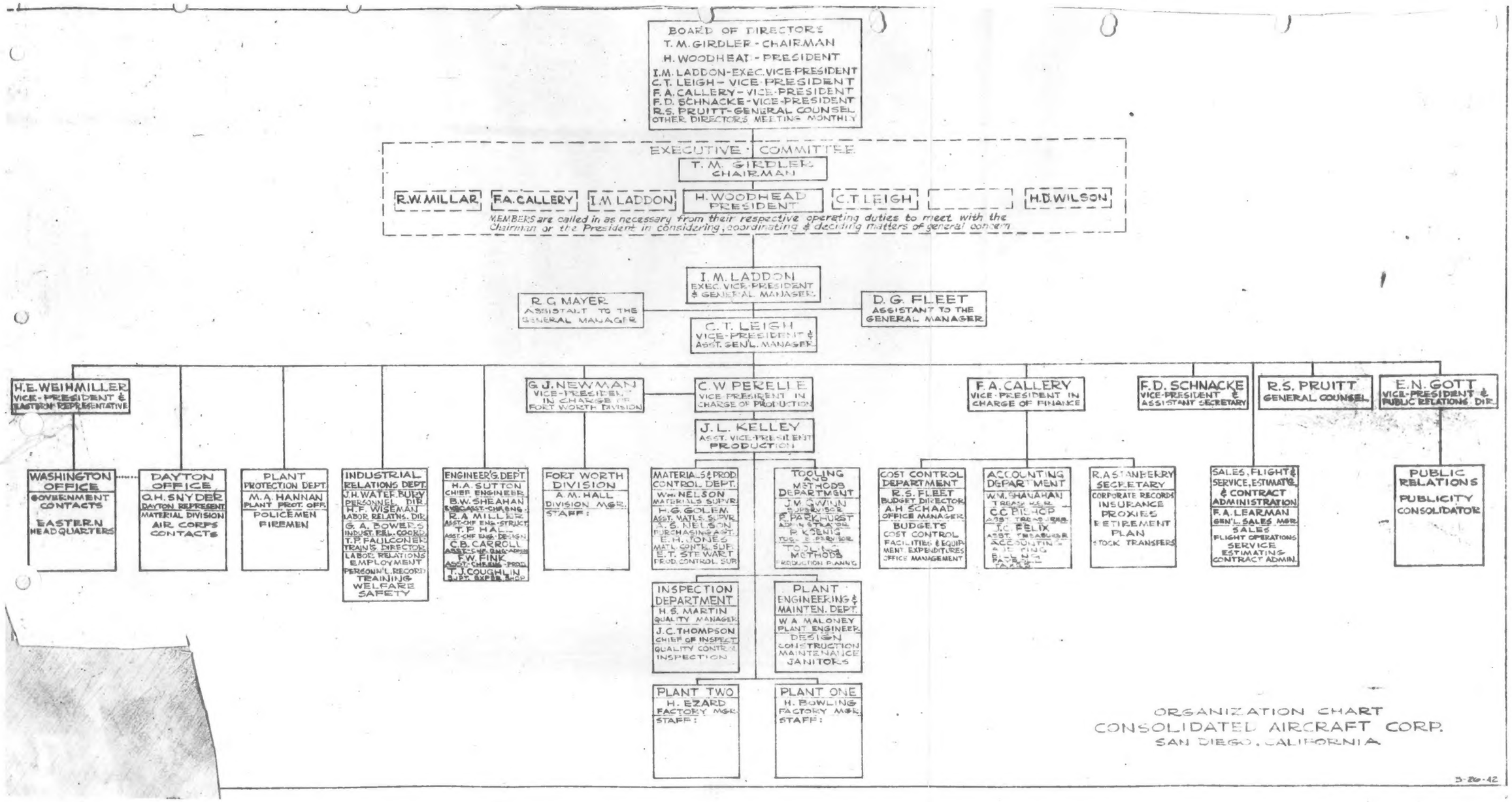
CONSOLIDATED AIRCRAFT CORPORATION
SAN DIEGO DIVISION

DECEMBER 1938
1938 SALES $12,245,000
AVERAGE NUMBER OF EMPLOYEES 2,042

CORPORATION

ORGANIZATION CHART





ORGANIZATION CHART
CONSOLIDATED AIRCRAFT CORP.
SAN DIEGO, CALIFORNIA

3-26-42

M-8095

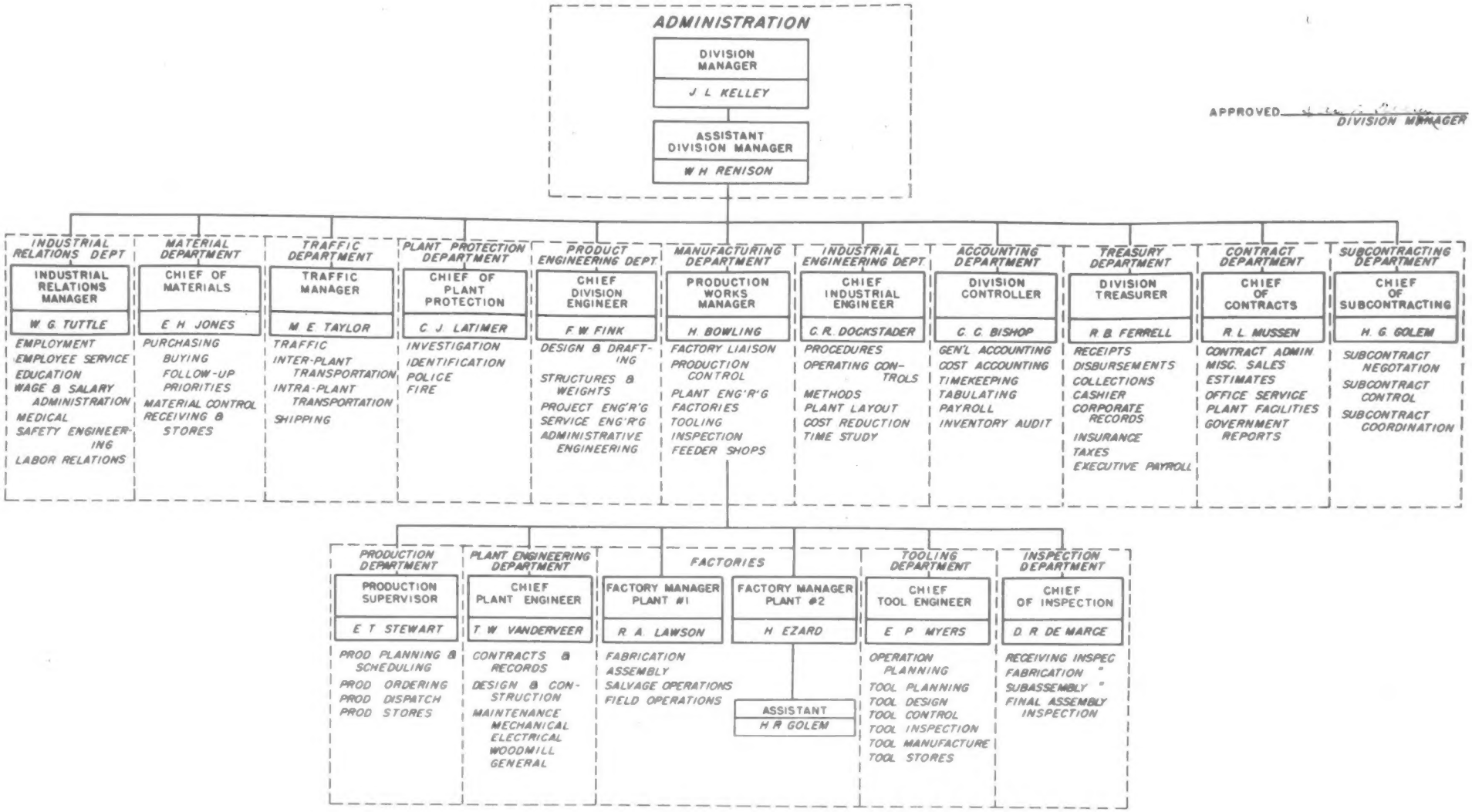
CONSOLIDATED VULTEE AIRCRAFT CORP
SAN DIEGO, CALIF

CHART NO. SDFI
REVISED: 9/9/43

FUNCTIONAL ORGANIZATION

SAN DIEGO DIVISION

APPROVED _____ DIVISION MANAGER



CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO, CALIFORNIA

CHART: #CO1
ISSUE: #1
DATE: 12/6/43

CORPORATION
ORGANIZATION CHART

BOARD OF DIRECTORS
○T. M. GIRDLER - CHAIRMAN

A. J. BRANDT
○ F.A.CALLERY
C.C.DARLING
V. EMANUEL
D.G.FLEET
J.HERTZ
J.M.HOUGHLAND
L.A.JOHNSON
○ I.M.LADDON
○ C.T.LEIGH
L.B.MANNING
D.N.MC DONNELL
G.W.PERELLE
R.S.PRUITT
W.C.SCHORLEMMER
○ H.D.WILSON
○ H.WOODHEAD

○ EXECUTIVE COMMITTEE

CONSULTANT TO THE CHAIRMAN — A. J. BRANDT

CONSULTANT — R.H.FLEET

PRESIDENT — H. WOODHEAD

APPROVED: H. Woodhead
PRESIDENT

ASSISTANT TO THE PRES. — E.N.GOTT
ASSISTANT TO THE PRES. — A.H.SCHAAD
ASSISTANT TO THE PRES. — D.G.FLEET
PUBLIC RELATIONS — A.J.PONTSTALL (SALES & AIRCRAFT TRAN)

EXECUTIVE VICE PRESIDENT — I. M. LADDON

PATENT DIRECTOR — G.T.GERLACH
GENERAL COUNSEL — R.S.PRUITT; R.F.T.RIGGS (ASSOCIATE)
STOUT RESEARCH DIVISION — W.B.STOUT (RESEARCH DIRECTOR); A.E.SHELTON (DIVISION MANAGER)
MASTER SCHEDULING DIRECTOR — H.S.MARTIN

VICE PRESIDENT — C.T. LEIGH

INDUSTRIAL RELATIONS DIRECTOR — F.A.LEARMAN
PURCHASING DIRECTOR — A.W.LARSEN
PLANT PROTECTION DIRECTOR — M.A.HANNAN

DIRECTOR OF ENGINEERING — H.A. SUTTON

ASST. TO THE DIR. OF ENGRG. — A.P.FONTAINE
ENGINEERING MANAGER — B.W.SHEAHAN
CHIEF DEV'M'T ENGINEER SAN DIEGO — T.P.HALL
CHIEF DEV'M'T ENGINEER VULTEE FIELD — C.R.IRVINE
CHIEF OF FLIGHT RESEARCH — E.D.SHANNON

VICE PRESIDENT OF MFG. — C. W. PERELLE

INDUSTRIAL ENGINEERING DIRECTOR — R.B.PARKHURST
ASST. TO THE V.P. OF MFG. — R.P.TIDMARSH
ASST. TO THE V.P. OF MFG. — C.A.SHARPE
SUBCONTRACT PRODUCTION PROD. CONTROL INSPECTION FIELD OPERATION
TOOLING DIRECTOR — J.M.G.WINN, JR.
PLANT ENGINEERING DIRECTOR — W.A.MALONEY
CHIEF OF MFG. RESEARCH — E.W.BERGER

VICE PRESIDENT OF FINANCE — F. A. CALLERY

PLANT FACILITIES DIRECTOR — R.S.FLEET
CONTROLLER — W.C.SCHORLEMMER
ASST. TO THE V.P. OF FINANCE — A.R.STERN
SECRETARY & TREASURER — W.M.SHANAHAN
ASSISTANT CONTROLLER — G.T.BOVEE
ASSISTANT CONTROLLER — L.K.GRANT
ASSISTANT SECRETARY & TREASURER — R.A.BUSSEY
INSURANCE DIRECTOR — R.R.MEYERS

GENERAL SALES MANAGER — F.A.LEARMAN

CONTRACT DIRECTOR — F.A.WATSON
FLIGHT AND SERVICE DIRECTOR — R.R.ROGERS
DAYTON REPRESENTATIVE — O.H.SNYDER
WASHINGTON REPRESENTATIVE — P.A.HEWLETT
FLIGHT DIRECTOR — D.T.KELLEY
SERVICE DIRECTOR — H.C.TAFE

ALLENTOWN DIVISION — R.J. MC MAHON, DIVISION MANAGER
ELIZABETH CITY DIVISION — L.H. COOPER, DIVISION MANAGER
FORT WORTH DIVISION — G. J. NEWMAN, DIVISION MANAGER
LOUISVILLE DIVISION — W. L. JONES, DIVISION MANAGER
MIAMI DIVISION — N.C.SATHER, DIVISION MANAGER
NASHVILLE DIVISION — J.W.HENNEN, DIVISION MANAGER
NEW ORLEANS DIVISION — W. NELSON, DIVISION MANAGER
SAN DIEGO DIVISION — J. L. KELLEY, DIVISION MANAGER
STINSON DIVISION — A. E. SHELTON, DIVISION MANAGER
TUCSON DIVISION — W. R. LAWRENCE, DIVISION MANAGER
VULTEE FIELD DIVISION — C. W. COSLOW, DIVISION MANAGER
CONSAIRWAY DIVISION — R.S.MITCHELL, DIVISION MANAGER

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